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GEOLOGISKA FÖRENINGENS
I STOCKHOLM
FÖRHANDLINGAR.
BAND 66. HÄFT. 2. N:o 437.

The Petrology of the Norra Kärr District.[1]

An Occurrence of Alkaline Rocks in Southern Sweden.

By

OLGE JUNGSTEDT ADAMSON.

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I. Introduction.

The Norra Kärr district was discovered by Professor A. E. Törnebohm and in quite a peculiar way. While examining some hand specimens collected by an assistant geologist of the Swedish Geological Survey, his attention was called to a very fine-grained grayish green rock »som ej liknade någon förut bekant svensk förekomst» (Törnebohm, 1906, p. 3).[1] He had thin sections made and found the rock to be nepheline-bearing. He further identified the rare zirconium silicates eudialyte and katapleite. The rock was named katapleite-syenite by Törnebohm. The circumstance that Törnebohm from a multitude of hand specimens picked out for closer investigation this rock, which has an altogether unremarkable appearance, is a good example of his famous intuition which, combined with his perhaps unequalled knowledge of Swedish rocks, led to so many remarkable results.

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[1] In translation: »not similiar to any previously known Swedish occurrence».

Subsequent field investigations showed that the grayish green rock occupied the greater part of a small area which also contained a series of other alkaline rocks. Törnebohm gave a review of the main geological features of the district together with a short description of the rocks (Törnebohm, 1906). A small sketch map was also reproduced. The publication further contained a number of chemical analyses carried out by the prominent mineral chemist R. Mauzelius. Advantage was not taken, however, of the analytical results, the analyses being quoted without any discussion of their bearing upon petrological problems.

Törnebohm himself emphasized that his work did not pretend to be a complete investigation of the district, either with respect to the field work or to the petrographical descriptions. ». . . dess närmaste ändamål var blott att åstadkomma den allmänna utredning af förekomstens geologiska och petrografiska förhållanden, som erfordrades för traktens under utgifning varande geologiska kartblad.»[1] Some of the minerals are, however, described in great detail. I wish to express my admiration for Törnebohms skilful and accurate microscopical work. If in a few cases I can hope to have improved upon it, this is only due to the development of petrographical methods of investigation since Törnebohm's paper appeared, in the first place the introduction of the immersion method and the universal stage.

Most occurrences of alkaline rocks in Fennoscandia are more completely described than was the Norra Kärr district. Two of them, viz. the Alnö and Fen districts, are already even the object of revisional work. The fact that revisions in these cases have proved to be necessary only a few decades after the pioneer work was done, is by no means due to any defects in the geological and petrographical descriptions, which, indeed, were brilliant in both cases (Högbom 1895, Brögger 1921). It is rather due to the development in our knowledge of the nature of alkaline rocks and to the introduction of new viewpoints concerning their mode of origin, which involves that the previous interpretation of the observations has to be reconsidered.

When I now present the results of my investigation of the Norra Kärr district, it is hoped that a revision thereof will not be found necessary in too short a time. A conception of the genesis of the Norra Kärr rocks must necessarily be rather speculative, since geological evidence concerning their interrelation is very scanty. The conclusion arrived at appears however to have a greater degree of probability than other hypotheses considered by the writer. It has been attempted to describe the observations without colouring the description by preconceived opinions in order to make them as applicable as possible to hypotheses other than that advocated in this paper.

---

[1] In translation: ». . . its foremost purpose was only to obtain a general survey of the geological and petrographical nature of the occurrence, as far as was necessary for the geological sheet covering the region, which was then in the course of publication.»

I visited the Norra Kärr district for the first time in May 1942. The mapping was then carried out on a scale 1 : 4000. After microscopical examination of the material collected, I paid a further visit to the field in August of the same year. I visited the district again in June 1943 for complementary work. The petrological study of the rocks was started in January 1942 (on material belonging to the Mineralogical Institute of Stockholms Högskola) and carried on almost continually, only interrupted by occasional consulting work. The results given in this paper are based upon field observations, examination of some 300 thin sections, 12 chemical rock analyses of which 9 are new and 8 complete mineral analyses of which 1 is new (the others are previously published in Törnebohm's paper) together with some partial chemical and spectrographical analyses.

The mineral analyses are interpreted in terms of the crystal structure of each mineral. [See Berman (1937) and Strunz (1941).] For this purpose the analyses are calculated so as to express the atomic relations. The method of treating the analyses is demonstrated under eckermannite, the composition of this mineral being among the most complex dealt with in this paper. Here it need only be mentioned that in each analysis the oxides are presented in order of increasing ionic radius of the metals in order to make it easier to group replaceable atoms together in the formula.

Concerning the determination of the optical properties of the minerals, it may be mentioned that the indices of refraction were determined by the immersion method. Unless otherwise stated ± 0.003 is the accuracy of the measurements given in this paper, the set of immersion liquids employed having an interval of 0.005 between successive liquids. The possible error is specially indicated when it must be considered as surpassing this value, as for example in minerals with so strong an absorption that it has proved impossible to enclose the index to be determined between two successive liquids.

The axial angles were measured on the universal stage. All optical constants were measured in sodium light.

In calculating the normative composition of the rocks and when working out the mineral analyses, von Eckermann's tables of molecular proportions have been used (1925). The mode of the rocks has been determined according to the Rosiwal method with an integration stage.

Concerning the use of symbols in referring to optical properties I have followed Larsen and Berman (1934). In the spelling of mineral names I have likewise followed this work with one exception, namely katapleite, which Larsen and Berman spelt with c as in most mineralogical literature written in English. The name was, however, derived from the Greek words *κατα* and *πλειον* (Weibye, 1850, p. 300), and should consequently be spelt with k.

The spelling nepheline is preferred to nephelite in accordance with a report of the committee on nomenclature of the Mineralogical Society of America (Kerr, 1936, p. 191).

II. Situation and Physiography.

The Norra Kärr district is situated on the eastern side of the great lake Vättern on the border between the provinces of Småland and Östergötland, about 1¹/₂ km from the shore. The exact geographical position is 58° 06′ N. lat. and 14° 40′ E. long. (from Greenwich). The whole district covers only some 0.3 square km. The form is oval with a greatest extension of 1200 metres in a north-south direction, and a maximum width of 400 metres. Most of the district lies inside Småland, the northern part of it extending about 200 metres into Östergötland. The greater part of the district is embraced by the farm Norra Kärr,[1] only a northern part belonging to the farm Lakarp and a southern part to the farm Kaxtorp.

The district forms a depression of a few metres depth in the surrounding Archean country. It has its maximum elevation in the north and slopes gently to the south. The difference in level between the highest and the lowest points hardly exceeds 20 metres. The average height above sea level is some 200 metres. The landscape consists of low birch-covered hills lying among small uneven fields and meadows interspersed with bogs and fir forest growth. In the northern part of the district bogs alternate with hills; in the central parts fields and meadows dominate, whereas in the south it is mostly fir forest and cultivated mire.

---

[1] Outside the district in a westerly direction lies a farm which is also called Norra Kärr. To avoid confusion only the farm situated inside the alkaline district will be referred to as the Norra Kärr farm. For the same reason the other farm is not designated by name on the accompanying map.

Along the eastern border runs a small watercourse, which, however, is dry in summertime as it is fed by boggy ground. The cultivated part is cut by a system of ditches, some of which contain an abundance of boulders from the underlying bed rock brought to the surface by the seasonal thawing.

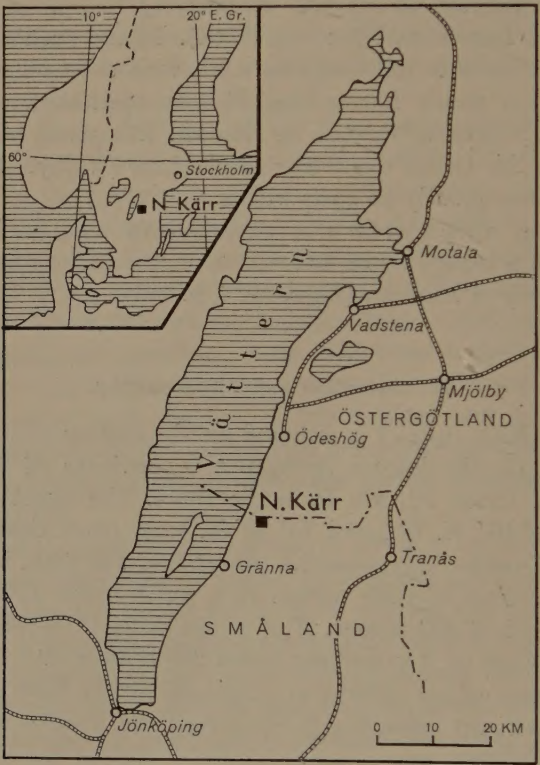

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Fig. 1. Situation of the Norra Kärr district.

The outcrops are most numerous in the northern half of the district, though they are not frequent even here. Solid rock is almost exclusively found on the top and the side of the small hills. Extensive exposures do not occur. By removing the moss, however, it is often possible to disclose the rock surface for some distance.

As to communications it may be mentioned that the stretch from the farm of Kaxtorp to the farm of Norra Kärr is passable by motor car as is the east—west track bordering the district to the south. The other passages marked on the map are only little better than horse-tracks.

III. General Geology of the Norra Kärr District and its Environs.

The Norra Kärr district constitutes an alien geological body inside the Archean of southern Sweden, which in this part of the country is represented by a biotite granite known by Swedish geologists as Red Växiö granite. Along Vättern it has a marked cataclastic schistosity in a north—south direction, but is elsewhere massive. It is generally coarse-grained but may in part be more fine-grained. The colour is due to a reddish microcline which sometimes may increase in magnitude to give the rock a somewhat porphyritic appearance.

Under the microscope it is seen that the granite consists of quartz, microcline perthite, plagioclase and biotite as main minerals, and magnetite, apatite, zircon and titanite as accessories. The microcline is perfectly fresh and shows the crosshatched twinning texture so characteristic of this mineral. The perthitic albite forms bands of 0.1—0.2 mm width and up to 3 mm length. It is always more or less turbid (due to sericitization). The largest bands show polysynthetic albite twins whereas in the smaller bands no twinning can be seen. The isolated plagioclase grains which occur to a much smaller extent than the microcline perthite also shows polysynthetic twinning according to the albite law. The plagioclase may, however, show so strong turbidization that the twinning cannot always be seen. The maximum extinction angle in the symmetric zone is 13°, corresponding to a composition $Ab_{90}An_{10}$. Biotite is a constant but not very abundant constituent. It shows a marked pleochroism from dark straw yellow to grass green colour. Parts of the biotite may be altered to chlorite and epidote. Biotite is generally the only dark main mineral but amphibole occurs occasionally.

The schistose variety of the Växiö granite occurring in the country along Vättern shows microscopic evidence of cataclastic structure such as strong undulation of the quartz and strain shadows in the microcline.

The chemical analysis of the Red Växiö granite given in Table 1 is quoted from Axel Gavelin's description to the sheet Tranås (1912 a, p. 16). The rock is very poor in magnesium which corresponds to the fact that it contains no pyroxene. The normative femic constituents are all accounted for by biotite and accessory minerals. Otherwise this granite has no peculiar chemical features.

In a distance up to about 100 metres from the contact with the Norra Kärr district the Växiö granite is transformed into syenitic and quartz-syenitic rocks, which, however, are structurally so similar to the unaltered granite that it is difficult to distinguish them in the field. The Norra

Table 1.

Analysis of Red Växiö granite, from Råsmäte in Säby parish, situated 20 km in a southeasterly direction from Norra Kärr (Gavelin 1912 a, p. 16).

Analyst: R. Mauzelius.

	Weight %	10 000 M	Norm		Niggli's system	
SiO_2	75.12	12 458	Q	33.72	qz	+ 188
TiO_2	0.25	31	Or	30.48	si	436
Al_2O_3	12.23	1 197	Ab	26.98	ti	1.09
Fe_2O_3	0.96	60	An	3.82		
FeO	1.34	187	C	0.01	al	42.0
MnO	0.07	10	Σ sal.	95.01	fm	16.0
MgO	0.53	132	en	1.33	c	5.0
CaO	0.84	150	fs	1.39	alk	37.0
BaO	0.04	3	il	0.47		
Na_2O	3.18	513	mt	1.39	mg	0.29
K_2O	5.14	546	ap	0.17	k	0.52
P_2O_5	0.07	5	pr	0.02		
H_2O	0.49	272	Σ fem.	4,77	c/fm	0.31
S	0.01	3	H_2O	0.49		
	100.27			100.27		

Kärr district is entirely enclosed by this rock, no alkaline dikes transversing the surrounding rock having been discovered. Starting from the southwestern corner the border line runs approximately north—south for 800 metres, describes a 300 metres arc to the east and continues 100 metres further to the north, whence it abruptly inclines eastward for about 200 metres. From this northeastern end of the district the borderline runs in a southerly direction for 600 metres, bends somewhat to the west and then closes the district with a curve. Thus the district is elongated in a north — south direction, parallel to the schistosity of the surrounding granite. The actual contact can only be studied at a couple of localities but the outcrops in the border zone generally lie close enough to allow a fixing of the border with an accuracy of 10 to 15 metres.

An aphanitic grayish green nepheline-bearing rock, generally containing katapleite and eudialyte, can be estimated to constitute more than 90 per cent of the whole alkaline district judging from the exposures. This main rock of the district stands in sharp contrast to the Växiö granite and its alteration products and is exposed all along the margin of the district.

The main rock is generally more or less schistose, seldom quite massive. The schistosity conforms with the contact against the granite as has already been pointed out by Backlund (1932, p. 8) and von Eckermann

(1942, p. 453). However, owing to the elongated form of the district, the conformity is not always obvious. Along the sides of the oval district the schistosity will be parallel to that of the granite, a circumstance which made Gavelin (1912 b, p. 30) assume that the schistosity of the alkaline district was secondary and probably due to the same regional movement which had deformed the granite. A closer study reveals however that the structure at both ends of the district does not follow the schistosity of the granite, on the contrary it may go in a direction at right angles to this. The conformity with respect to the boundary may be studied particularly well in the southwestern corner of the district where the gradual bow of the structure can be followed from metre to metre. It is thus probable that the structure is primary protoclastic and consequently has no connection with the secondary cataclastic schistosity of the Växiö granite. This circumstance has a bearing upon the problem of the age of the Norra Kärr district which will be considered in another chapter.

The general geological structure of the Norra Kärr district can be studied in the accompanying map. Besides the dominant aphanitic rock, the district contains a series of alkaline rocks occurring as inclusions. Common to all of them and texturally distinguishing them from the main rock is a phanerocrystalline development. Their mode of occurrence, which will be discussed under the description of the respective rocks, strongly suggests that they are older than the main rock. Törnebohm (1906, p. 18), not having access to chemical analyses, treated all of them as a group under the name lakarpite though he was fully aware of their different petrographical character: »Afsikten med användandet af den föreslagna termen är icke att införa ett nytt petrografiskt namn, ty de förekomster som den afser, kunna — oaktadt deras uppenbara genetiska samhörighet — ej rätt väl bringas in under en gemensam petrografisk definition, utan meningen är blott att för tillfället få ett bekvämt gemensamt uttryck för de egendomliga 'dioritiska' bergarter, som skola beskrifvas.»[1] Further investigation showed that a subdivision of this group was necessary, and thus the term lakarpite in Törnebohm's sense had to be eliminated. It proved impossible to find old petrographical names which would distinguish all these peculiar rocks, and as it was too inconvenient to refer to them in terms of their mineral components, there was no alternative but to invent new names. It should, however, be emphasized that it is not intended to charge petrographical nomenclature with new terms. It would indeed be imprudent to suggest a new term only represented by a few hundred square metres of rock. The names should only be regarded as »convenient words by which various rocks in an area may be distinguished» (Johannsen 1938, IV, p. V). These names are based upon a description and not a definition, which implies that they should not be used for rocks outside the Norra Kärr district unless they are altogether identical. The essential mineral compounds presented in brackets after each rock name may serve as a characterization of the rocks.

---

[1] »The intention in using the term proposed is not to invent a new petrographical name, because the occurrences it refers to cannot be covered by a common petrographical definition in spite of their evident genetical connection. The meaning is only to get a convenient common expression for the peculiar »dioritic» rocks to be described, for the time being.»

The word »dioritiska» (dioritic) is put in quotation marks by the present author.

I have retained the term lakarpite for the rock whose main occurrence is situated on the farm Lakarp.

IV. Description of the Alkaline Rocks.

A. The Main Rock. Grennaite

(eudialyte—katapleite—micro—nepheline—syenite).

The main rock of the district was referred to by Törnebohm (1906, p. 5) as katapleite syenite. This term however is not a proper designation and that for two reasons. In the first place: The term *syenite* in itself involves a phanerocrystalline texture, whereas the rock in question has an aphanitic groundmass. In the second place: Eudialyte is as characteristic a constituent of the rock as katapleite and moreover katapleite is not invariably present.

A microscopical examination of the rock shows the presence of the following minerals: alkali fledspar, nepheline, aegirite, eudialyte, katapleite and natrolite, of which the five first mentioned are regular constituents whereas natrolite has a more accidental mode of occurrence. Katapleite only occurr as phenocrysts and has euhedral forms. The texture of the groundmass can best be characterized as xenomorphic granular, the constituent minerals having anhedral to subhedral boundaries.

The rock can be divided into several types according to the total and relative abundance of eudialyte and katapleite and to the development of these minerals. Dependent upon whether the rock is porphyritic or not, two main types can be distinguished, which after a microscopical study can be further subdivided:

I. Porphyritic, with phenocrysts of the zirconium silicates eudialyte and katapleite.
   1. With much zirconium (phenocrysts of katapleite, and eudialyte in the groundmass).

2. With less zirconium (phenocrysts of eudialyte, and eudialyte in the groundmass.)

II. Nonporphyritic, without phenocrysts either of katapleite or eudialyte.

1. With a certain zirconium content (eudialyte in the groundmass).
2. Zirconium free (no zirconium silicates).

The most abundant type is I 1, which has phenocrysts of katapleite and so much eudialyte in the groundmass that it may quantitatively dominate over katapleite. This type with all transitions is connected with the types which contain no katapleite. Only in some places is the rock completely devoid of both katapleite and eudialyte. For geological reasons the different types must be treated in common. They appear as a geological unity of rocks, the components of which have been formed simultaneously under the same physical and approximately the same chemical circumstances, only differing in the zirconium concentration. For field work it is therefore necessary to have one term comprising all types and as such I have used the term grennaite, after the small town of Gränna (Grenna), situated some 10 kilometres from Norra Kärr.

a. Field Observations.

Grennaite with phenocrysts of katapleite constitutes more than 70 per cent of all outcrops in the district. On a fresh surface the katapleite rystals are difficult to detect. They have a grayish white colour which causes them almost to isappear in the grayish green roundmass. On a weathered urface, however, the katapleite henocrysts can be seen at several metres distance. The groundmass hen has a dirty green colour which is in sharp contrast with he white weathering product of he katapleite. Katapleite also hows a somewhat greater resistnce to weathering than the roundmass and therefore has a ertain relief in relation to it.

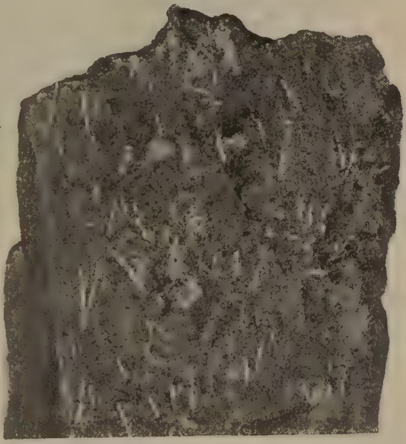

Fig. 2. Grennaite with needlelike phenocrysts of katapleite. Weathered surface. Natural size. (Reproduced from Törnebohm, 1906, p. 5.)

The katapleite crystals are ubject to great variations both

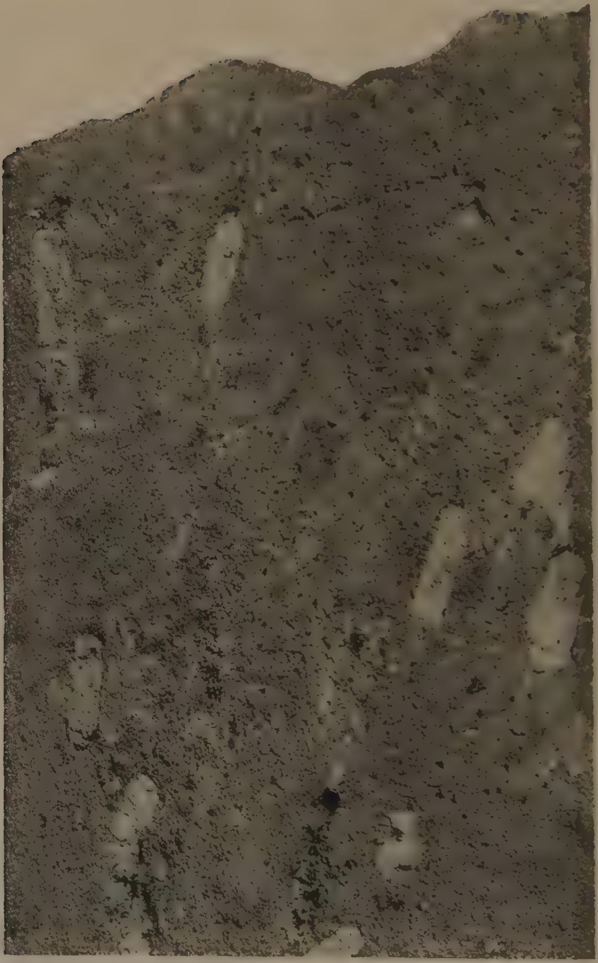

Fig. 3. Grennaite with large katapleite laths. Weathered surface. Natural size. (Reproduced from Törnebohm, 1906, p. 6.)

as to their size and their abundance. They vary from 2 mm long needles to laths 20—30 mm in length (Figs. 2 and 3). Their abundance is inversely proportional to the size. When they are needle-like the rock is crowded with them, whereas the largest crystals occur several centimetres apart. Common to all of them is a pronounced euhedral development.

The frequency of the different katapleite-bearing grennaite varieties may be studied in the accompanying map, the magnitude of the dashes indicating the magnitude of the katapleite phenocrysts. Katapleite aths of medium length — about 10 mm — are most common. Grennaite vith needlelike katapleite crystals is the most rare variety.

Grennaite with phenocrysts of eudialyte (Fig. 4) is only observed at our localities, all of them situated along the border of the district, ut here they occupy a considerable area. In contrast to katapleite he eudialyte phenocrysts are easily detected on a fresh surface, having

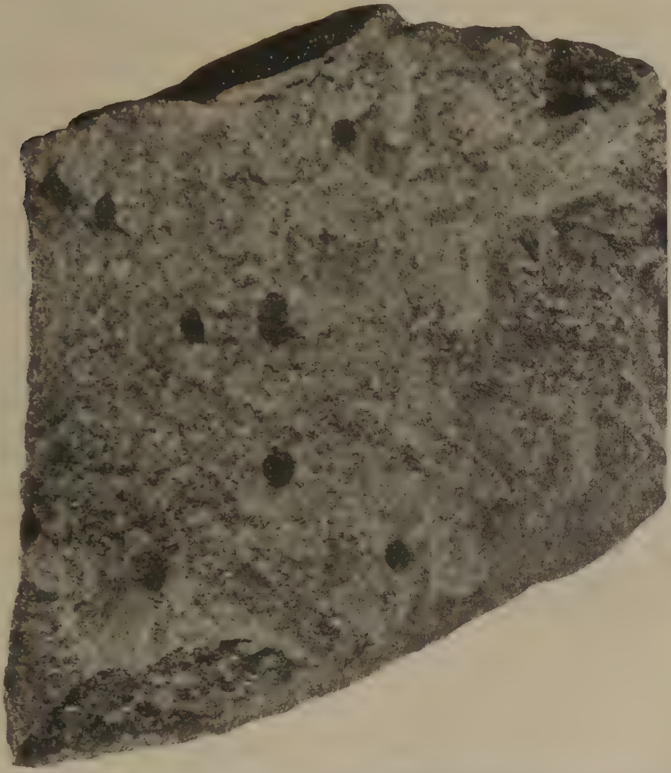

Fig. 4. Grennaite with phenocrysts of eudialyte. Fresh surface. Natural size. (Reproduced from Törnebohm, 1906, p. 8.)

bright rose colour. On a weathered surface, however, no eudialyte ndividuals can be seen. They are more easily weathered than the roundmass, so that their former positions are marked by cavities in he rock. The form of the eudialyte phenocrysts is approximately pheroidal or ellipsoidal and they may have diameters from 5 to 20 mm.

Transitional types between grennaite with phenocrysts of katapleite nd grennaite with phenocrysts of eudialyte contain both katapleite and udialyte phenocrysts. It is remarkable that the katapleite crystals in his case do not have their usual euhedral development but have oval forms like the eudialyte crystals. In this grennaite type phenocrysts having cores of katapleite and mantles of eudialyte are sometimes seen. Composite crystals showing the reverse relation i.e. core of eudialyte with katapleite mantle are never observed.

Grennaite without phenocrysts either of katapleite or eudialyte occupies only small areas of a few square metres extension. This type occurs always in connection with grennaite containing phenocrysts of eudialyte. It has an appearance similar to the groundmass of the other grennaite types. The groundmass is so fine-grained that none of the minerals can be distinguished with the naked eye.

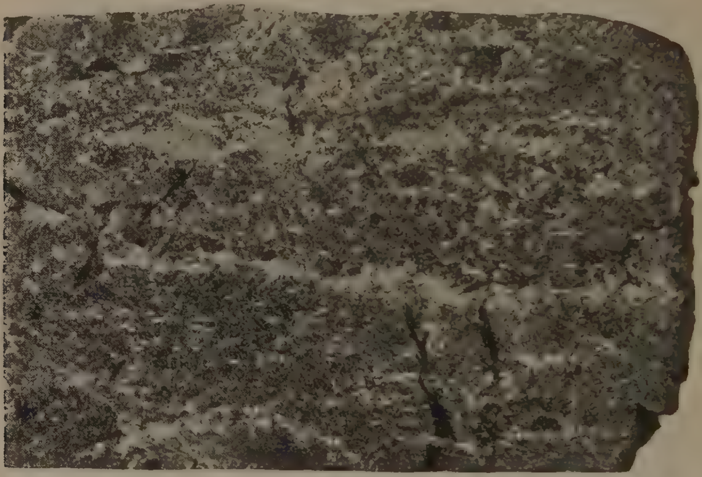

Fig. 5. Strongly schistose grennaite with light streaks consisting essentially of katapleite. Fresh surface. Natural size. (Reproduced from Törnebohm, 1906, p. 7.)

The colour of grennaite is generally grayish green but is more reddish in the type containing eudialyte phenocrysts. There is every degree of transition between the extreme colours. Common for all types of grennaite are sporadically distributed phenocrysts of feldspar. They are rather inconspicuous and are first detected by closer inspection of the rock. They are seldom larger than 2—3 mm across and are without crystallographic boundaries.

The schistosity of the grennaite is not equally easily recognized in the different types. On account of their lath-like shape the katapleite phenocrysts greatly contribute to setting off the structure of the rock, the largest diameter of the crystal being oriented parallel to the schistosity. When no phenocrysts are present it may be difficult to decide whether the rock is massive or schistose. In some places the katapleite henocrysts have been broken up and the katapleite substance forms treaks throughout the rock (Fig. 5).

b. Mineral Description.

The Feldspar Group. The main component of the groundnass is feldspar. The individuals show no twinning, so it is difficult to letermine their character by the usual optical methods. Chemical nalyses have, however, shown that they belong to the anorthoclase roup of alkali feldspars. Some sporadically distributed phenocrysts lso consist of feldspar, as previously mentioned. According to optical roperties they are albite and microcline.

Chemical analyses of the feldspar were carried out by R. Mauzelius. s appears from statements by Törnebohm (1906, pp. 7, 17) the feldspar as isolated in the following way: Nepheline and natrolite were first xtracted from the grennaite by treatment with hydrochloric acid. The eldspar was then separated from aegirite, katapleite and eudialyte by eavy liquids.

The material thus obtained consisted of all feldspar in the grennaite, oth the feldspar of the groundmass and that of the phenocrysts. In uantity the latter only plays a subordinate role. Törnebohm (p. 7) rote (in translation): »By isolation from the pulverised rock the main art of the feldspar was found to have a specific gravity between 2.58 nd 2.618. Of this two fractions were taken, one with specific gravity 58—2.60, the other with specific gravity 2.607—2.618. Alkali deterinations proved that the first fraction (by far the smaller one) conined Na$_2$O: 5.47 %, K$_2$O: 8.99 %, and the second Na$_2$O: 8.91 %, $_2$O: 4.01 %». There is nothing to indicate that the feldspar of the roundmass is inhomogeneous. Therefore, in all probability, the fraconation of the feldspar material is due to the feldspar phenocrysts. t should here be mentioned in advance that many of the phenocrysts e composed of both microcline and albite. Microcline, having the nallest specific gravity of these feldspars, will be found in the first action. The comparatively high sodium content of this fraction is lieved to be due to grains derived from the composite feldspar phenoysts, the components of which have not been completely separated y the pulverisation of the rock. The heavier fraction will contain all e feldspar of the groundmass and possibly albite from the phenoysts. Allowing a small correction for the possible presence of albite, is analysis Na$_2$O: 8.91, K$_2$O: 4.01 can be considered to represent the ntent of alkalis in the groundmass feldspar.

The composition of the heavier fraction can be calculated on the basis of these determinations:

SiO_2	67.40	Weight%
Al_2O_3	19.04	»
Na_2O	8.91	»
K_2O	4.01	»
	99.36	Weight%

It is seen to be a very pure alkali feldspar. The analysis corresponds with a feldspar composed of 75.3 % Naf and 23.7 % Kf.[1] It is thus anorthoclase according to the common conception of this term (Alling, 1921, p. 233).

All feldspar grains of the groundmass are perfectly fresh. The variation in refractive indices of different grains do not exceed the limits of error of the immersion method. The indices of refraction were found to be:

α: 1.523
β: 1.528
γ: 1.530

The axial angle is $2\ V\alpha = 46°$.

The phenocrysts of feldspar evidently belong to the same generation as the feldspar of the groundmass. With a few exceptions they show no tendency to euhedral development. They are small, only about 2 mm across, and there are seldom more than two or three in each thin section. Many thin sections are completely devoid of feldspar phenocrysts.

Some phenocrysts are homogeneous and consist of microcline with the usual crosshatched twinning texture of this mineral, or of albite generally polysynthetically twinned after the albite law. Many phenocrysts have, however, a complex texture. Some phenocrysts have a core of albite and a mantle of microcline, sometimes surrounded with another mantle of albite. Other phenocrysts have a core of microcline and a mantle of albite, sometimes surrounded with another mantle of microcline. The distribution of these two types of phenocrysts in the rock is quite fortuitous. A zone nearly always had a corroding effect upon the one lying within it. In spite of the corrosion the original euhedral boundaries of the core can generally be distinguished. The different zones of a phenocryst always have the same orientation, and in the two zones of soda feldspar or the two zones of potash feldspar the indicatrix has the same position.

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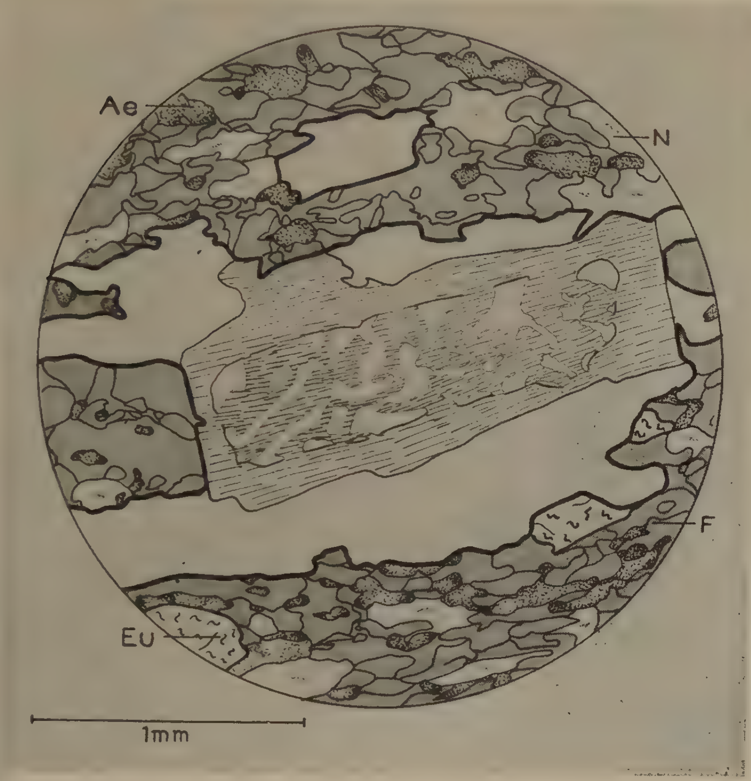
[1] The symbols Kf and Naf are preferred to Or and Ab generally used because Or and Ab »mentally stand for definite mineral phases, such as orthoclase, that may not exist in the combination considered». (Andersen, 1929, p. 145.)

An oriented intergrowth of two feldspar components is generally alled perthite. However, the texture just mentioned differs from verything which has hitherto been described as perthitic intergrowth nd it may be doubted whether it is justifiable to apply the term in this ase. I prefer to describe it as zonal intergrowth of soda- and potash-dspar. The peculiar character of the texture may be illustrated by ew examples:



g. 6. Composite feldspar phenocryst in grennaite. (Bounded by heavy lines.) A core untwinned albite (white) is strongly resorbed by potash feldspar (long dashes) which surrounded by an outer layer of albite (white). The phenocryst is corroded by the undmass, in the upper half of the picture even isolating a part of the phenocryst. F: anorthoclase, N: nepheline, Ae: aegirite, Eu: eudialyte. Magnification: c. 35.

1. A phenocryst of oval form has a maximum diameter of about nm (Fig. 6). At some places the granular groundmass has grown into but in the main the border against the groundmass is rather sharp. e phenocryst consists of three zones: an inner one of albite, surrounded

by potash feldspar, which in turn is surrounded by albite. There is no
twinning seen in any of them. Examination in convergent light reveals
that the potash feldspar is in optical continuity with the albite zones.
The phenocryst is cut approximately perpendicular to an optical axis
and all three zones give the same interference figure, an isogyre curved

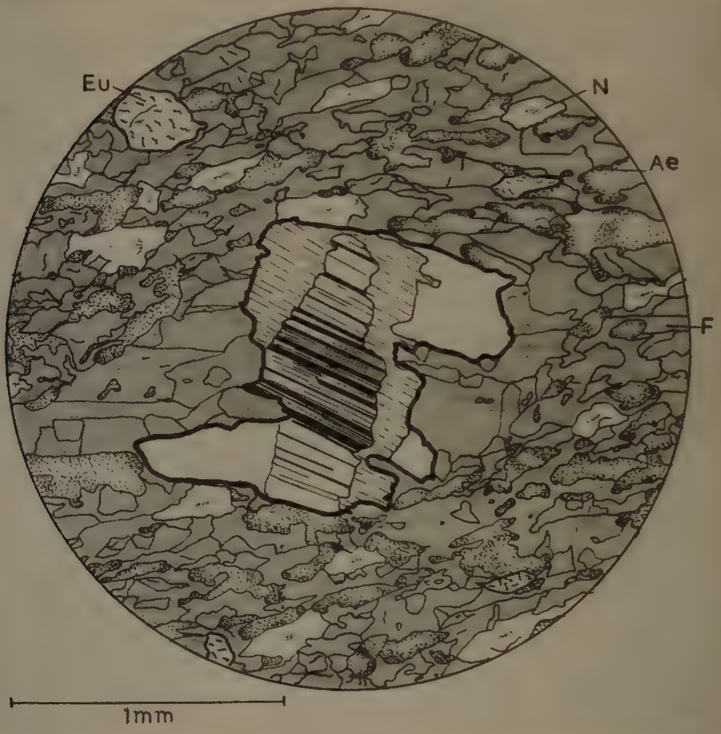


Fig. 7. Composite feldspar phenocryst in grennaite. (Bounded by heavy lines.) The core consists of polysynthetically twinned albite surrounded by successive layers of potash feldspar and untwinned albite. Key as Fig. 6. Magnification: c. 35.

so as to indicate an axial angle of about 70° for the albite and 60° for the potash feldspar. Whether the potash feldspar is microcline or orthoclase cannot be established, but it is most probably microcline, since this is the case in all phenocrysts where it has been possible to identify the character of the potash feldspar.

The core of albite has been strongly resorbed by the potash feldspar; its original outline can however be clearly distinguished. It has crystallized as a perfectly euhedral individual of rectangular shape. The surrounding microcline is only subhedral, having the form of a somewhat irregular oval. The outer zone of albite has had no perceptible resorbing effect upon it. This albite zone has quite anhedral boundaries. It is so resorbed by the groundmass that a part of it has been detached from the main crystal.

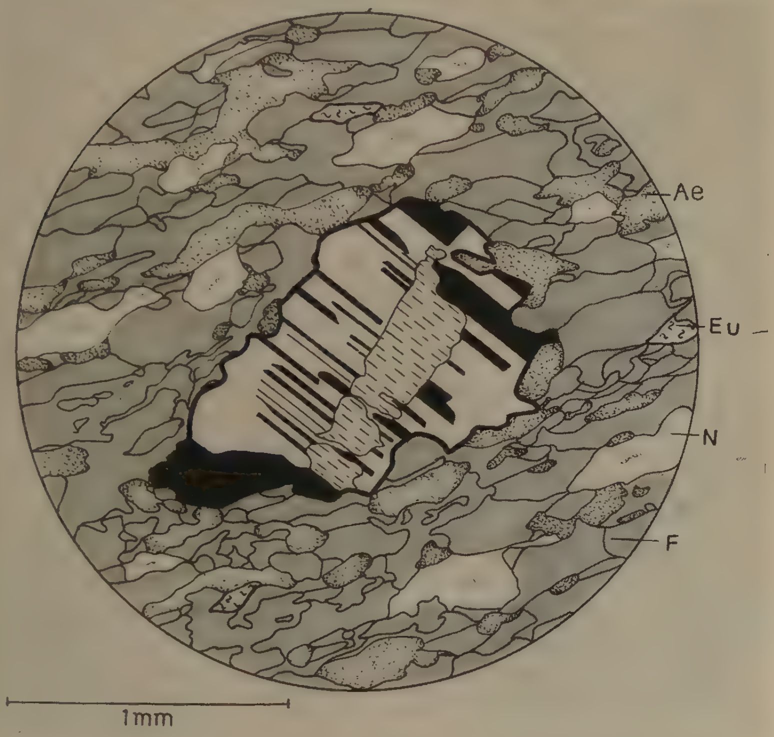


Fig. 8. Composite feldspar phenocryst in grennaite. A core of untwinned potash feldspar is resorbed by surrounding albite with polysynthetical albite twins. Key as Figs. 6 and 7. Magnification: c. 35.

2. A phenocryst of one mm length (Fig. 7) has a core of albite with multiple albite twins surrounded by untwinned potash feldspar which again is surrounded by albite with the same orientation as the first mentioned but without albite twins. The shorter direction of the albite core runs parallel to the twinning. Both ends are straight but the sides have the form of irregular steps. The surrounding potash feldspar only encloses $^3/_4$ of the albite core. It has had an insignificant resorbing effect upon the albite. The outer zone of albite is strongly resorbed by the

groundmass, this for the greater part being in direct contact with the potash feldspar zone.

3. Another phenocryst (Fig. 8) consists of two zones only. It has a core of untwinned potash feldspar, euhedrally bounded. The albite enclosing it is polysynthetically twinned after the albite law. The twinning is parallel to the shorter side of the phenocryst. The albite has resorbed the potash feldspar mainly in a direction parallel to the albite twins, the albite sending offshoots into the core and even penetrating it. Resorption has been most complete in one end of the core, only a small isolated part with the same orientation as the main crystal remaining. The albite zone is anhedrally bounded by the groundmass.

4. A phenocryst consists of a core of microcline with charcateristic crosshatched twinning texture surrounded by a rim of albite showing no twinning. The length is one mm. The microcline is euhedrally bounded. The albite has broken through one of the faces and resorbed the inner part of the microcline crystal. The groundmass in its turn has had a strong resorbing effect upon the albite and has also found its way into the centre of the microcline core.

5. A phenocryst has a core of albite surrounded by a rim of microcline. It is 1.5 mm long. The albite is anhedral and has multiple albite twins. The microcline shows beautiful crosshatched twinning texture. The twinning of the albite runs parallel to one set of the microcline twins.

It has been found justifiable to assume that the lighter fraction of the feldspar separation contained the microcline phenocrysts together with some grains from the composite phenocrysts. Even if the analysis of this fraction thus cannot be considered to have been carried out on homogeneous material, a calculation of the results is nevertheless of interest in establishing the character of the material as pure alkali feldspars. The composition calculated on the basis of the alkali determinations, Na_2O: 5.47, K_2O: 8.99 is:

SiO_2	66.43	Weight %
Al_2O_3	18.76	»
Na_2O	5.47	»
K_2O	8.99	»
	99.65	Weight %

thus proving the material to consist of exceedingly pure alkali feldspars.

Feldspar crystals of a texture similar to that of the feldspar phenocrysts in grennaite have been described by Magnusson (1923, p. 305—312) in the rock särnaite from the province of Dalarna in Sweden. (Särnaite is the name of a nepheline-syenite carrying cancrinite as an essential mineral. Brögger, 1890, p. 244.) Magnusson wrote: »The alkaline feldspars principally consist of tables with the M-face well developed and composed of cores of an orthoclase rich in soda surrounded by mantles of albite.» They may also have more than one mantle: »A peculiarity that is sometimes observed in the main type of Siksjöberget is that the albite mantle is in turn overgrown by orthoclase with the same orientation and optical characters as the orthoclase in the core.» The albite component of the composite crystals also is in parallel orientation with the orthoclase components, as is seen from the following passage from Magnusson: »In the nepheline-syenite from Umptek described by V. Hackmann (Fennia, 1894), albite mantles are often observed around the feldspar tables. Hackmann points out that this albite is not orientated parallelly with the orthoclases of the cores but that the two constituents are subparallelly or less regularly orientated towards each other. In the särnaites of Ekorråsen and Siksjöberget, on the contrary, the albite in the mantles always is orientated parallelly with the orthoclase of the core.»

There is, however, one textural difference between the feldspar crystals in särnaite and those in grennaite. In särnaite the core of a crystal always consists of orthoclase, whereas in grennaite individuals with a core of potash feldspar and individuals with a core of soda feldspar both occur.

I can see no way of interpreting the zonal texture of layers of potash- and soda-feldspars other than by assuming a successive crystallization of the components. For the formation of his so-called interlocking perthite, Andersen (1929, p. 186) has offered an interesting theory which may well be applied to the composite feldspar phenocrysts of the grennaite. It gives a quite satisfactory interpretation of all features mentioned under the description of the phenocrysts:

»We consider, for instance, the microcline part of the growing perthite at a moment when the liquid in contact with this part is saturated with both feldspars. At first microcline will separate on the crystal already present, the liquid thus becoming relatively richer in andesine and poorer in microcline. If the microcline, as presumed, has a relatively large surface its growth will demand a supply of material from a considerable volume of the liquid. Unless the liquid has an excessively high fluidity a state may then be reached at which the diffusion can no longer keep pace with the growth; the liquid in contact with the crystal will cease being saturated with microcline and the crystallization of the microcline must stop. At the same moment the andesine will begin crystallizing in parallel orientation with the microcline and this will continue as long as the diffusion is able to keep the liquid which is in contact with the crystal saturated with andesine. When the andesine can no longer crystallize, microcline will again separate and so forth. The contact faces between the two feldspars »may be compared with the boundary faces between individual layers in zonal crystals and are more strikingly characterized as faces of deposition than as faces of intergrowth.» (Ussing).»

Concerning the resorption processes, Andersen says (p. 202): »The process of simultaneous rhythmical crystallization, such as it is outlined above, has consisted in oscillations between a state characterised by growing microcline and stationary plagioclase and another state characterised by growing plagioclase and stationary microcline. Now these stationary stages of the microcline and plagioclase may be replaced by stages of resorption without any essential change in the process. Indeed, if the possibility of any such oscillations be granted it seems reasonable that the culmination points should be represented by one feldspar dissolving and the other one crystallizing rather than by one feldspar at rest and the other one crystallizing, provided only that the total effect of the processes of resorption be less than the total effect of the processes of crystallization (otherwise no final solidification would result).»

Nepheline. In unweathered grennaite nepheline is perfectly fresh. Owing to the absence of twinning in the feldspar of the groundmass nepheline is easily confused with this mineral. It is almost impossible to distinguish the nepheline, unless a grain happens to have such an orientation that it gives a clear uniaxial interference figure. However, by etching the thin section with hydrofluoric acid and colouring it with aniline, the nepheline assumes a more rose colour than the feldspar and can thus be distinguished from this mineral. The indices of refraction of the nepheline are:

$$\omega\colon 1.532$$
$$\varepsilon\colon 1.529.$$

In thin sections of weathered grennaite it is seen that the nepheline has altered to a light brown substance with lower index of refraction. This substance has very much the same appearance as the alteration product of nepheline in kaxtorpite (see p. 194), which has been analyzed and proved to be natrolite.

An analysis of nepheline together with its calculation is presented in Table 2. It is seen to be a very sodium-rich nepheline. Two other nephelines, regarded to be sodium-rich, are given in Table 3 for comparison.

Table 2.

Analysis of nepheline from grennaite.

Analyst: R. Mauzelius, 1906.

	Weight %	Mol. numb.	Numb. of O	Numb. of metal atoms + O		
SiO_2	43.56	0.7224	1.4448	1.00		1
Al_2O_3	32.51	0.3181	0.9543	0.88	0.89	1
Fe_2O_3	0.33	0.0021	0.0063	0.01		
Na_2O	18.34	0.2958	0.2958	0.82	0.89	1
CaO	0.42	0.0075	0.0075	0.01		
K_2O	2.32	0.0246	0.0246	0.06		
H_2O	2.88	0.1554	0.1554	0.43		
	100.36		2.8887			

$$f = \frac{4}{2.8887} = 1.3847$$

Table 3.

	1	2	3
SiO_2	43.56	44.08	46.41
Al_2O_3	32.51	34.71	31.07
Fe_2O_3	0.33	—	0.78
FeO	—	—	
MgO	—	—	0.11
Na_2O	18.34	16.46	15.67
CaO	0.42	2.51	0.87
K_2O	2.32	3.17	3.81
H_2O+	2.88	0.45	0.97
H_2O-			0.17
	100.36	101.38	99.86

1. Nepheline from grennaite, Norra Kärr.
2. Nepheline, Monte Somma, Mt. Vesuvius, Italy (Bannister, 1931, p. 572. Analyst: M. H. Hey).
3. Nepheline from phonolite, 53 miles from Nairobi on Nairobi-Nyeri road, Kenya (Bowen and Ellestad, 1936, p. 365. Analyst: Ellestad).

Bannister (1931, p. 590) found that nepheline which is low in K_2O, is also low in refractive index and that nepheline which is rich in K_2O is high in refractive index. For the nepheline of column 2, Table 3, Bannister found by measuring two crystals that ω was 1.5341 and 1.5304 respectively, whereas for a nepheline with 5.66 per cent K_2O (p. 572) he found ω to be as much as 1.5394 (p. 590). In accordance with the result of Bannister, the indices of refraction of the nepheline from Norra Kärr are very low.

Aegirite. Aegirite is the only dark mineral in grennaite. It forms grains 0.1—0.2 mm long, generally somewhat smaller than the

Table 4.

Analysis of aegirite from grennaite.

Analyst: R. Mauzelius, 1906.

	Weight %	Mol.numb.	Numb. of O	Numb. of metal atoms and O		
SiO_2	53.78	0.8919	1.7838	2.02		2
Al_2O_3	3.93	0.0384	0.1152	0.17	0.98	1
TiO_2	0.06	0.0007	0.0014	0.00		
Fe_2O_3	27.19	0.1703	0.5109	0.77		
MgO	0.22	0.0055	0.0055	0.01		
FeO	0.77	0.0107	0.0107	0.02		
MnO	0.15	0.0021	0.0021	0.01		
Na_2O	12.76	0.2058	0.2058	0.93	0.97	1
CaO	0.80	0.0143	0.0143	0.03		
K_2O	0.27	0.0029	0.0029	0.01		
H_2O	0.08	0.0044				
	100.01		2.6526			

$$f = \frac{6}{2.6526} = 2.2619$$

feldspar and nepheline individuals. The grains may be more or less elongated. In the massive types of grennaite the aegirite grains are always regularly distributed all over the thin section, but in the schistose types they have often gathered in streaks. The optical properties are:

$$X \wedge c = 3°$$
$$2V\alpha = 58°$$

X: dark green, Y: grass green, Z: yellowish green

$$X > Y > Z$$

Dispersion is distinct $r > v$.

The chemical analysis (Table 4) shows that it is a very pure aegirite, corresponding closely to the formula $NaFe^{III}Si_2O_6$.

Eudialyte. This mineral is easily recognized under the microscope by its high indices of refraction. By lowering the analyzer or decreasing the light, the high relief of the eudialyte makes it rise over the other minerals in the groundmass. The eudialyte is colourless in thin sections of usual thickness. The interference colours are weak, and the mineral has diffuse extinction. The low double refraction renders observations in convergent light difficult. Sometimes, however, a diffuse uniaxial cross is obtained, which always shows optical positive character. The optical negative equivalent of eudialyte, eucolite, was never observed.

Table 5

Analysis of eudialyte from pegmatitic schlieren of grennaitic composition.

Analyst: R. Mauzelius, 1906.

	Weight %	Mol.numb.	Numb. of O	Numb. of metal atoms and O, OH, F, Cl		
SiO_2	47.85	0.7935	1.5870	6.01		6
Ta_2O_5	1.22	0.0028	0.0140	0.04	0.89	1
TiO_2	0.11	0.0014	0.0028	0.01		
ZrO_2	13.39	0.1092	0.2184	0.84		
ΣCe_2O_3	2.97	0.0211[1]	0.0633	0.32	5.93	6
ΣY_2O_3	3.90	0.0390[1]	0.1170	0.60		
MgO	0.08	0.0020	0.0020	0.01		
FeO	2.92	0.0406	0.0406	0.31		
MnO	2.69	0.0379	0.0379	0.29		
Na_2O	13.19	0.2127	0.2127	3.27		
CaO	7.63	0.1360	0.1360	1.05		
K_2O	0.51	0.0054	0.0054	0.08		
H_2O	2.64	0.1465	0.1465	2.25	2.47	2
F	0.32	0.0169	0.0169	0.13		
Cl	0.43	0.0121	0.0121	0.09		
	99.85		2.6126			
Less O for F, Cl	0.23	$\div \frac{0.0290}{2} =$	0.0145			
	99.62		2,5981			
		$f = \frac{20}{2.5981} = 7.6979$				

The size of the eudialyte grains in the groundmass is somewhat larger than that of most feldspar grains. All individuals have a similiar shape and show a certain tendency to idiomorphism. The forms are somewhat rounded, but generally a pseudorhombic habit is perceptible. The amount of eudialyte may vary from one locality to another, but its distribution in the groundmass is rather uniform, with no accumulation of grains in certain parts of the thin section.

As mentioned the phenocrysts of eudialyte can megascopically be seen to have a bright rose colour. They have the same optical properties as the eudialyte grains belonging to the groundmass.

The indices of refraction are

$$\omega: 1.617$$
$$\varepsilon: 1.621.$$

The analysis (Table 5) was not carried out on material from the grennaite itself, because it was not possible to obtain material of sufficient purity from this rock. The analyzed material was selected from the pegmatitic schlieren of grennaitic composition to be described on

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[1] The molecular weights 340 for ΣCe_2O_3, and 250 for ΣY_2O_3 were used.

Table 6.

	1	2	3	4	5	6	7	8	9	10	11	12
FeO	6.36	5.01	7.12	6.08	1.79	6.15	6.08	3.20	6.49	6.65	2.92	5.6
ΣLa_2O_3	0.34	0.52	1.37	1.75	2.12	2.54	2.56	2.95	4.58	5.19	6.87	22.5
ω	1.608	1.604	1.610	1.613	1.593	1.617	1.613	1.624	1.618	1.621	1.617	1.643
ε	1.610		1.611				1.612	1.630	1.616	1.618	1.621	
$\varepsilon \div \omega$	+0.002		+0.001	÷0.003	+0.004	÷0.003	÷0.001	+0.006	÷0.002	÷0.003	+0.004	÷0.009

1. Eudialyte, Hackmannschl. (Kunitz, 1936).
2. Mesodialyte, Ljawajoka (Kostylewa, 1929).
3. Eudialyte, Kakasnjujakok (Kunitz, 1936).
4. Eucolite, Chibinpachkčorr (Kostylewa, 1929).
5. Eudialyte, Angvundasčorr (Kostylewa, 1929).
6. Eucolite, Neptunit-Höhlung, (Kostylewa, 1929).
7. Eucolite, Kangerdluarsuk (Kunitz, 1936).
8. Eudialyte, Rume, Los Archip. (Kunitz, 1936).
9. Eucolite, Brevik (Kunitz, 1936).
10. Eucolite, Lille Arö (Brögger, 1890).
11. Eudialyte, Norra Kärr.
12. Eucolite, Madagascar (Lacroix, 1915).

p. 150. The calculation shows a quite satisfactory correspondence to the formula: $Na_3Ca(Fe^{II}, Mn, \Sigma La)_2 Zr(Si_3O_9)_2 (OH, F, Cl)_2$.

As compared with other eudialyte and eucolite analyses the most remarkable feature is an unusually high content of lanthanides. With the exception of an extremely lanthanide-rich eucolite from Madagascar, described by Lacroix (1915, p. 278), the highest lanthanide content in these minerals that I have been able to find in the literature is a eucolite from Langesundsfjord containing 5.19 per cent lanthanides (Brögger, 1890, p. 504). Kunitz (1936, p. 427) has made a compilation of eucolite and eudialyte analyses from different parts of the world and according to his table two to three per cent of lanthanides seems to be the most common value.

Kunitz (1936, p. 428) found that the indices of refraction of eudialyte and eucolite increased with the amount of lanthanides present.

The values for the indices of refraction of the eudialyte from Norra Kärr do not contradict this statement. However, the variation in refractive index is also dependent upon other components. According to Kostylewa (1929) we have chiefly to reckon with iron. In Table 6 the content of iron and lanthanides in the eudialyte from Norra Kärr together with the indices of refraction, are compared with corresponding values for eudialyte and eucolite from different localities taken from a table compiled by Kunitz[1] (1936, p. 427). The analyses are arranged according to increasing amounts of lanthanides.

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[1] Kunitz evidently has confused the optical sign of eudialyte with that of eucolite. In his table there also is a thorough disagreement between the indices of refraction and the optical signs given.

Katapleite. Katapleite generally occurs as phenocrysts, the shape and mode of occurrence of which have already been described. A single grain of about 0.5 mm length may sometimes be seen in the groundmass.

Megascopically katapleite is seen to have a grayish white colour. In thin sections, however, it is colourless. A yellowish or reddish pigmentation sometimes present indicates that the mineral is slightly altered. Owing to the high interference colours katapleite is easily recognized under the microscope. By observation in convergent light it gives a beautiful, almost uniaxial interference figure of positive character. By rotation the balks will open about 5°. The indices of refraction are:

$$\alpha \sim \beta: 1.585$$
$$\gamma: 1.603.$$

Dispersion is distinct $r < v$.

In the mineralogical tables of Larsen and Berman (1934, pp. 109, 164) katapleite is reported to be partly biaxial positive with an axial angle up to 25°, and partly biaxial negative with large axial angle. The indices of refraction presented for positive katapleite are those of katapleite from Narsarsuk as given by Böggild (1906, p. 113): α: 1.591, β: 1.592, γ: 1.627. The indices of refraction of the katapleite from Norra Kärr are, however, seen to be more close to the optically negative katapleite in the tables of Larsen and Berman, for which the following values are given: α: 1.575, β: 1.590, γ: 1.605. The indices of refraction as well as the double refraction of the katapleite from Norra Kärr are somewhat lower than those given in the tables.

For katapleite from Langesundsfjord, which is optically negative, Brögger (1890, p. 442) estimated the axial angle to be about 60°. By heating a thin section, he found that at 140° C the mineral became uniaxial. On cooling it regained its former properties. Flink (1899, p. 98) and Böggild (1906, p. 111) made similiar observations on the katapleite from Narsarsuk but found that it had varying reversion temperatures. The circumstance that the katapleite from Norra Kärr is nearly uniaxial even at normal temperatures distinguishes it from the specimens from the two other localities mentioned.

Twinning seems to be rather common in the katapleite from Langeundsfjord and Narsarsuk as described by Brögger and Böggild respectvely. In the katapleite from Norra Kärr, however, twinning has not een observed. This is another feature distinguishing it from the other pecimens.

For the same reason as given under the description of eudialyte, the hemical analysis has been carried out on material selected from the egmatitic schlieren of grennaitic composition. The analysis (Table 7)

Table 7.

Analysis of katapleite from pegmatitic schlieren of grennaitic composition.

Analyst: R. Mauzelius, 1906.

	Weight %	Mol.numb.	Numb. of O	Numb. of metal atoms and O		
SiO_2	43.69	0.7245	1.4490	2.91		3
ZrO_2	32.00	0.2610	0.5220	1.05		1
Fe_2O_3	0.27	0.0017	0.0051	0.01	1.89	2
Na_2O	12.62	0.2036	0.2036	1.64		
CaO	3.12	0.0556	0.0556	0.22		
K_2O	0.24	0.0026	0.0026	0.02		
H_2O	8.63	0.4790		H_2O : 1.92		H_2O: 2
	100.57		2.2379			

$$f = \frac{9}{2.2379} = 4.0216$$

corresponds well with the formula $(Na_2, Ca)\, ZrSi_3O_9 \cdot 2H_2O$, representing half the content of the unit cell as determined by Brunowsky (1935, 1936).

As a primary mineral katapleite is only known from a few localities. Apart from the type locality Langesundsfjord, it has been described from Narsarsuk, Norra Kärr and Mt. Khibines[1] (Kostylewa, 1932). As an alteration product of eudialyte it is rather common. As such it has been described in an aegirite-nepheline-syenite in the Los archipelago (Lacroix, 1911, p. 31) and in kakortokite from Greenland (Ussing, 1911, p. 178).

Natrolite. In certain parts of the grennaite, natrolite may be rather abundant, whereas in other parts it may be altogether absent. It occurs partly in isolated individuals, partly in aggregates of smaller grains and partly in veins replacing particularly nepheline but also feldspar. The natrolite is colourless and generally clear but may occasionally be somewhat turbid. It is easily distinguished from nepheline and feldspar by its relatively high interference colours and by its low indices of refraction. Natrolite veins eating through nepheline and feldspar grains are found exclusively in the schistose types of grennaite. The massive grennaite only contains natrolite material filling out the interspaces between the previously crystallized mineral grains.

Natrolite shows a distinct interference figure of positive character. The axial angle 2V is 60°. The indices of refraction are:

α: 1.478
β: 1.483
γ: 1.492.

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[1] At the request of the editor, A. A. Polkanov, of the guide-book for the northern excursion of the 17th International Geological Congress, the spelling Khibine is given preference to Chibine (1937, p. 51).

Table 8.

Analysis of natrolite from grennaite.

Analyst: R. Mauzelius, 1906.

	Weight %	Mol.numb.	Numb. of O	Numb. of metal atoms and O	
SiO_2	47.35	0.7852	1.5704	2.99	3
Al_2O_3	26.99	0.2641	0.7923	2.01	2
Na_2O	16.21	0.2615	0.2615	1.99	2
CaO	0.08	0.0014	0.0014	0.005	
K_2O	0.16	0.0017	0.0017	0.01	
H_2O	9.37	0.5201		H_2O: 2.08	H_2O: 2
	100.16		2.6273		

$$f = \frac{10}{2.6273} = 3.8062$$

The analysis (Table 8) is seen to be in exceedingly good agreement with the formula $Na_2Al_2Si_3O_{10} \cdot 2H_2O$.

In a few thin sections one or two minute grains of a colourless, isotropic mineral with low index of refraction have been observed. Törnebohm (1906, p. 10) believed it to be sodalite. On the same page Törnebohm mentioned that in a few cases he had observed grains of a mineral which appeared to be pectolite. It is probable that this observation was made in a thin section from the border zone against kaxtorpite, the extension of which rock Törnebohm did not seem to have realized, judging from his sketch map (1906, p. 4; the »lakarpite» body situated S—SW of the farm Norra Kärr). In grennaite I have observed no mineral which might be pectolite.

A few grains of fluorite have occasionally been observed in grennaite.

c. Petrographical Character.

The zirconium concentration of the grennaite is represented by katapleite and eudialyte. Katapleite contains nearly double as much zirconium as eudialyte. The presence of katapleite therefore signifies a higher zirconium concentration in the rock.

Microscopical investigation shows that there is a remarkable difference n the modes of occurrence of katapleite and eudialyte. When grennaite contains katapleite, this mineral is developed as phenocrysts, whereas the eudialyte is restricted to the groundmass. When grennaite contains phenocrysts of eudialyte, katapleite is altogether absent, except in the transitional types between grennaite with phenocrysts of katapleite and grennaite with phenocrysts of eudialyte. Thus katapleite is always accompanied by eudialyte, whereas eudialyte may occur alone.

All varieties of grennaite containing katapleite phenocrysts have a fairly constant amount of eudialyte in the groundmass. This is, however, not the case with the grennaite type containing phenocrysts of eudialyte. Then there is a certain relation between the amount of eudialyte in the groundmass and the size and quantity of the eudialyte phenocrysts. The greater the amount of eudialyte phenocrysts is, the smaller is the amount of eudialyte in the groundmass. In the most extreme varieties with eudialyte phenocrysts of 20 mm diameter, the eudialyte may be almost absent in the groundmass. The total amounts of eudialyte in the katapleite-free grennaite varieties are, however, not greater than those in the katapleite-bearing grennaite varieties.

The groundmass of the grennaite is almost even-grained with an average grain diameter of 0.2 mm. It shows the same fineness of grain throughout the district from the border to the central regions. The eudialyte grains are generally somewhat larger than the grains of feldspar and nepheline, whereas the aegirite grains are usually a little smaller. Feldspar and nepheline are entirely anhedral, but eudialyte and aegirite may show a tendency to euhedral development. The schistosity is recognized in the microscope by a distinct subparallel arangement of the mineral grains. Within a certain distance from the phenocrysts, the grains diverge from the general direction of schistosity and follow the borderline of the phenocrysts. The texture shows every evidence of being precrystalline.

As has been mentioned above, the size of the katapleite phenocrysts may vary from small needles to laths 30 mm in length, all of which have a euhedral development. The idiomorphism is most pronounced in the smaller individuals. The larger ones are usually only euhedral in the prismatic zone, being subhedrally terminated at the ends. Sometimes, however, the prisms are bounded by pyramidal faces. A phenocryst is often corroded by the groundmass, sometimes even separating it into several parts (Fig. 9).

The katapleite phenocrysts generally have inclusions of the groundmass minerals: feldspar, nepheline and aegirite, particularly the two first-mentioned. They form small, rounded equidimensional grains of almost the same size which are altogether anhedral (Fig. 10). It is worth mentioning that eudialyte has not been observed as an inclusion. The phenocrysts contain inclusions to a varying extent, the smaller phenocrysts generally having less inclusions than the larger ones. As a rule it can be said that the less pronounced the idiomorphism of the phenocryst is, the greater is the number of inclusions.

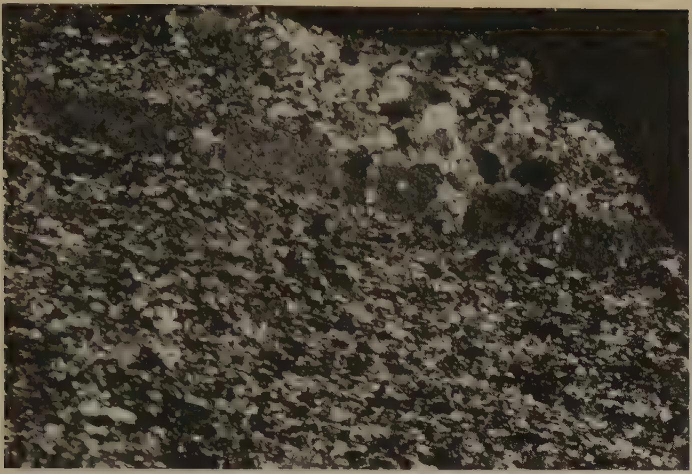

Fig. 9. Grennaite with a corroded phenocryst of katapleite in the upper half of the picture. The dark mineral is aegirite; the light minerals are essentially anorthoclase and nepheline. × nicols. Magnification: 10.

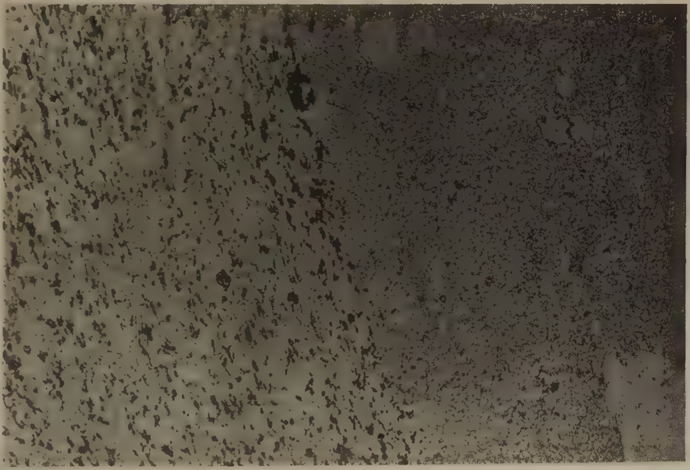

Fig. 10. Grennaite with large phenocryst of katapleite. The katapleite crystal (the right half of the picture) is crowded with inclusions of feldspar and nepheline. In the groundmass (the left half of the picture) eudialyte can be distinguished from the other light minerals by its sharper outlines. // nicols. Magnification: 10.

The eudialyte phenocrysts are never euhedral as are the katapleite phenocrysts. They are rounded, sometimes with faintly subhedral outlines. With respect to inclusions, the eudialyte phenocrysts show the same features as the katapleite phenocrysts. The texture of these inclusions is quite irregular and dense, no arrangement along any preferred direction being perceptible. This texture is thus in striking contrast to the general subparallel texture of the groundmass. The large phenocrysts may be so crowded with inclusions that when working without analyzer the phenocrysts appear like aggregates of mineral grains. However, with crossed nicols the katapleite's and eudialyte's character of host crystals is established by the common optical orientation of the katapleite »grains» and eudialyte »grains» respectively. Sometimes there may be more inclusions in the peripheral parts of a phenocryst than in the centre. Here the inclusions may even dominate over the host crystal, so that the phenocryst is split up into a number of isolated parts. If a phenocryst has poorly defined outlines, peripheral parts may at first sight give the impression of being constituents of the groundmass, their belonging to the phenocryst being recognized only by the common optical orientation.

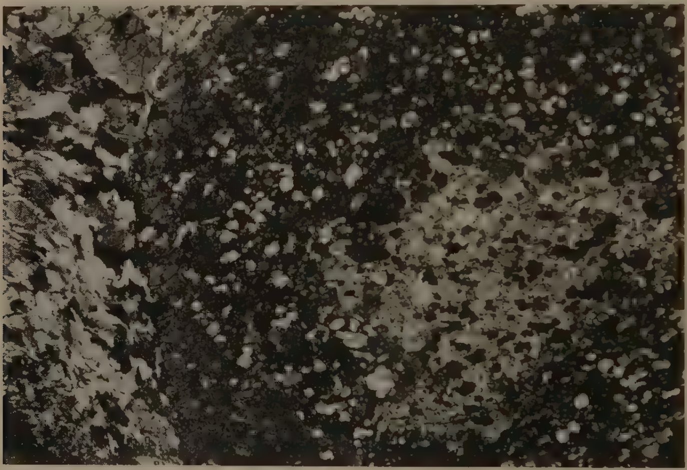

Fig. 11. Composite phenocryst consisting of a core of katapleite and a rim of eudialyte. The katapleite core is seen at the lower right of the picture surrounded by the dark eudialyte rim. The katapleite as well as the eudialyte are crowded with inclusions of feldspar and nepheline. The groundmass of grennaite is seen to the left. × nicols. Magnification: 10.

The composite phenocrysts consisting of a core of katapleite and a mantle of eudialyte shows no difference in the arrangement of the inclusions incorporated in katapleite and those in eudialyte. Without analyzer a composite phenocryst cannot be distinguished from a homogeneous phenocryst, it being impossible to point out where transition occurs from katapleite to eudialyte. With crossed nicols, however, the

Table 9.

Analysis of grennaite with phenocrysts of katapleite. Norra Kärr.

Analyst: R. Mauzelius, 1906.

	Weight %	10 000 M	Norm		Mode, Vol %	Niggli's system	
SiO_2	56.75	9 411	Or	23.00	Feldspar, phenocrysts 3	qz	÷ 95
TiO_2	0.03	4	Ab	37.08		si	194
ZrO_2	1.60	131	Nef.	26.99	Feldspar, groundmass ($Kf_{24}Naf_{75}$) 48	ti	0.08
Al_2O_3	21.10	2 065	Hl.	0.07		zr	2.68
Fe_2O_3	2.29	143	Z	2.40			
FeO[1]	0.23	32	Σ sal.	89.54	Nepheline 29	al	42.6
MnO	0.12	17			Aegirite 8	fm	7.3
MgO	0.08	20	wo	1.55	Eudialyte 7	c	2.8
CaO	0.76	136	en.	0.20	Katapleite 5	alk	47.3
Na_2O	11.66	1 881	ac	4.72	Natrolite		
K_2O	3.88	412	Na_2SiO_3	1.48		mg	0.06
P_2O_5	0.01	1	il.	0.06	100	k	0.18
H_2O	1.69		mt	0.95			
Cl	0.04	11	ap.	0.03		c/fm	0.38
S	0.03	9	pr	0.06			
	100.27		Σ fem.	9.05			
Less O for Cl, S	0.02		H_2O	1.69			
	100.25			100.28			

Quantitative System: I : 6 : 1 : 4, Miaskose.

katapleite is easily distinguished from eudialyte by its higher interference colours (Fig. 11).

d. Chemical Composition.

Chemical analysis have been carried out on two types of grennaite: grennaite with phenocrysts of katapleite and grennaite with phenocrysts of eudialyte. The first analysis (Table 9) was published by Törnebohm (1906, p. 11). According to him this grennaite had katapleite phenocrysts of up to 4 centimetres length. The original analysis gives no information as to the content of ferrous iron. For the sake of completeness a ferrous iron determination was made on material selected from the original locality as described by Törnebohm. The grennaite of which the second analysis (Table 10) was carried out had eudialyte phenocrysts of about two centimetres diameter.

The first analysis can be taken as representative of by far the greater part of the Norra Kärr district, the different varieties of katapleite-bearing grennaite probably having only slight variations in chemical composition. Except for the zirconium contents the two analyses of

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[1] The determination of ferrous iron has been carried out by A. Bygdén, 1942.

Table 10.

Analysis of grennaite with phenocrysts of eudialyte. Norra Kärr.

Analyst: Thelma Berggren, 1943.

	Weight %	10 000 M	Norm		Mode, Vol %		Niggli's system	
SiO_2	57.95	9 942	Or	22.83	Feldspar,		qz	: 80
TiO_2	0.04	5	Ab	43.95	phenocrysts	4	si	203
ZrO_2	0.32	26	Nef.	25.99	Feldspar,		ti	0.1
Al_2O_3	22.04	2 157	Hl.	0.04	groundmass		zr	0.5
Fe_2O_3	2.62	164	Z	0.48	(Kf_{24},Naf_{76})	56		
FeO	0.76	106	Σ sal	93.29	Nepheline	28	al	44.2
MnO	0.02	3			Aegirite	7	fm	9.1
MgO	0.03	7	wo	0.51	Eudialyte	5	c	1.0
CaO	0.29	52	en	0.07	Natrolite		alk	45.7
SrO	< 0.002		ac	2.78		100		
BaO	0.00		Na_2SiO_3	0.02			mg	0.02
Na_2O	11.24	1 813	il	0.07			k	0.18
K_2O	3.85	409	mt	2.41				
P_2O_5	0.03	2	ap	0.05			c/fm	0.11
SO_3	0.00		fr	0.02				
$H_2O > 105°$	0.41		Σ fem	5.93				
$H_2O < 105°$	0.10		H_2O	0.51				
F	0.01	5						
Cl	0.03	8		99.73				
	99.74							
Less O for F, Cl	0.01							
	99.73							

Quantitative System: I : 6 : 1 : 4, Miaskose.

grennaite show no great differences. For most determinations the variations are almost within the limits of analytical error. The small amount of zirconium in Table 10 as compared with Table 9 might be expected, since this grennaite type contains only eudialyte which has a much snaller content of zirconium than katapleite. Törnebohm (1906, p. 11) reported that a partial analysis of one specimen of grennaite gave as low a value as 53.8 % for SiO_2. This figure ought to be very close to the minimum limit for the acidity of grennaite.

As seen from the analyses, grennaite is of a highly sodic character. The high alkalinity of the rock is demonstrated by the fact that *alk* > *al* in terms of Niggli's conceptions and by the presence of normative Na_2SiO_3. Grennaite is further characterized by an overwhelming preponderance of ferric iron over ferrous iron. The content of lime is very low, and the amounts of manganese and magnesium insignificant. Chemically the most characteristic feature of grennaite is its content of zirconium which for the katapleite-bearing types has one of the highest values known for alkaline rocks.

Table 11.

	1 a	1 b	2	3	4	5	6	7	8
SiO_2	56.75	57.95	53.68	54.14	53.44	55.50	55.51	55.31	56.24
TiO_3	0.03	0.04	1.35	0.95	0.30	0.30	0.94	1.18	0.26
ZrO_2	1.60	0.32		0.92	1.00	1.16	0.86	0.31	0.09
Al_2O_3	21.10	22.04	18.42	20.61	18.64	19.87	18.90	19.56	21.43
Fe_2O_3	2.29	2.62	5.91	3.28	9.38	3.34	6.02	1.92	2.01
FeO	0.23	0.76	2.57	2.08	0.86	0.76	0.22	3.17	0.55
MnO	0.12	0.02	0.75	0.25	0.10	0.60	tr	0.28	0.08
MgO	0.08	0.03	0.88	0.83	none	0.28	0.37	0.76	0.15
CaO	0.76	0.29	2.05	1.85	0.79	1.63	1.56	1.53	1.38
SrO		<0.002						0.00	0.03
BaO		0.00						0.06	0.08
Na_2O	11.66	11.24	9.46	9.87	12.10	9.91	12.85	10.32	10.53
K_2O	3.88	3.85	4.92	5.25	2.43	5.41	2.04	4.67	5.74
P_2O_5	0.01	0.03			none	absent	none	0.19	0.06
Nb_2O_5							0.11		
SO_3		0.00							0.10
$H_2O > 105°$	1.69	0.41	0.89	0.40	1.12	0.94	0.63	0.55	0.86
$H_2O < 105°$		0.10			0.34	0.24	0.21	0.09	0.12
F		0.01					0.23	0.33	tr
Cl	0.04	0.03		0.12	0.12	0.31		0.00	0.12
S	0.03					absent			0.03
	100.27	99.74	100.88	100.55	100.62	100.25	100.45	100.23	99.86

1 a. Grennaite with phenocrysts of katapleite. Norra Kärr.
1 b. Grennaite with phenocrysts of eudialyte. Norra Kärr.
2. Eudialyte-lujavrite. Tsutsknjun, Lujavr-Urt, Kola (Ramsay, 1898, p. 16. Analyst: W. Petterson).
3. Eudialyte-rich chibinite. Tschasnatschoor, Umptek, Kola (Ramsay and Hackmann, 1894, p. 132. Analyst: Eichleiter).
4. Aegirite-lujavrite. Tupersuatsiak, S. Greenland (Ussing, 1911, p. 168. Analyst: C. Winther).
5. Eudialyte-rich foyaite. Buffelskloof, S. Africa (Shand, 1928, p. 130. Analyst: Shand).
6. Zircon-mariupolite. Kamienny-Row, Mariupol, U.S.S.R, (Morozewicz, 1930, p. 346. Analyst: Morozewicz).
7. Nepheline syenite. Kiihtelysvaara, Finland, (Eskola-Sahlstein, 1930 a, p. 3. Analyst: L. Lokka).
8. Phonolite. Pleasant Valley, Colfax Co., Utah (Clarke, 1900, p. 171. Analyst: W. F. Hillebrand).

In the quantitative system grennaite has the position I : 6 : 1 : 4, Miaskose.

Comparing grennaite with other rocks it is seen from Table 11 that t is closely related to lujavrite and chibinite in chemical composition. Eskola-Sahlstein (1930 a, p. 4) pointed out the similarity between grenaite and a nepheline-syenite found as a boulder in Kiihtelysvaara, inland (No. 7 in Table 11), emphasizing that titanium in the Finnish ock plays the role of zirconium in grennaite. Except for the zirconium ontent, grennaite also very much resembles certain phonolites (No. 8 n Table 11).

e. Marginal Facies of Grennaite.

The boundary of the grennaite with the surrounding granite is exposed at two localities. For a distance of one to two metres from the contact grennaite is here seen to have a white colour. The white grennaite is further observed at three localities, where the boundary is itself not exposed, but which we can estimate to be situated less than two metres from the contact, judging from the general trend of the border line. This rock is not found in the inner parts of the Norra Kärr district. These circumstances should give sufficient evidence for the supposition that the white rock is a marginal facies of the usual grayish green grennaite, which must be expected to occur all around the margin of the district.

The contact is particularly well exposed at a locality in the northwestern corner of the district. Here it can be seen how the white marginal facies grades into the usual grayish green grennaite. The change of colour from green to white is due to a decreasing amount of aegirite, as can be confirmed by a microscopical study of the rock. In one of the localities phenocrysts of eudialyte or katapleite are missing, but in the others they are abundant as in ordinary grennaite. It is therefore probable that the absence of phenocrysts at the one locality is only local and has nothing to do with influence from the contact. A boulder of about two metres size, representing the transition from ordinary grennaite to the marginal facies, is found in the northern end of the district, 5 metres from the border. This boulder contains an abundance of katapleite and eudialyte phenocrysts, which show no variation in distribution from that part of the boulder consisting of typical grennaite to that consisting of the white rock. The rose coloured crystals of eudialyte in a white groundmass here give the marginal facies a very conspicuous appearance.

The eudialyte and the katapleite of the marginal facies have quite the same appearance as in ordinary grennaite, and so have feldspar, nepheline and natrolite. The aegirite of the marginal facies has however a lighter colour than usual. It is pale yellowish green with insignificant pleochroism. The extinction angle is the same as for usual aegirite, $X \wedge c = 3°$. This aegirite very much resembles that of a nepheline-sodalite-syenite from Northern Rhodesia, described as aluminous aegirite by Adams and Osborne (1932, p. 573). According to the description it is practically colourless and ». . . shows very faint pleochroism in brown and green in the prismatic sections». It is very probable that the light colour of the aegirite of the marginal facies of grennaite from Norra

Table 12.

Analysis of the marginal facies of grennaite. Norra Kärr.

Analyst: A. Bygdén, 1942.

	Weight %	10 000 M	Norm		Mode, Vol %		Niggli's system	
SiO_2	55.06	9 131	Or	26.35	Feldspar,		qz	÷ 116
TiO_2	0.002		Ab	28.67	phenocrysts	2	si	181
ZrO_2	1.04	85	Nef	40.30	Feldspar,		zr	1.68
Al_2O_3	24.86	2 432	Z	1.56	ground-			
Fe_2O_3	0.26	16			mass	49	al	48.2
FeO	0.48	67	Σ sal	96.88	Nepheline	38	fm	2.2
MnO	0.018	3	wo	0.24	Aegirite	1	c	0.4
MgO	0.04	10	en	0.03	Eudialyte	5	alk	49.2
CaO	0.12	21	fs	0.24	Katapleite	5		
SrO	0.00		fo	0.05	Natrolite		mg	0.09
BaO	0.00		fa	0.37			k	0.19
Na_2O	12.46	2 010	Na_2SiO_3	0.61		100		
K_2O	4.45	472	mt	0.37			c/fm	0.18
P_2O_5	0.00		pr	0.01				
$H_2O > 105°$	0.95		Σ fem	1.92				
$H_2O < 105°$	0.32							
S	0.01		H_2O	1.27				
	100.07			100.07				

Quantitative System: I : 7 : 1 : 4, Laugenose.

Kärr is due to a partial replacement of the ferric iron of ordinary aegirite by aluminium.

Fluorite is occasionally seen, forming streaks running in a direction parallel to the schistosity.

On comparing the analysis of the marginal facies (Table 12) with that of normal grennaite, it is seen that the main difference lies in the contents of iron, the marginal facies having much less ferric iron. We have undoubtedly had a migration of iron from the margin of the grennaite body into the surrounding granite, a supposition which is verified by the mineralogical and chemical relations of the fenite to be described later on. The mineralogical consequences of this migration upon the grennaite have been a decrease in the amount of aegirite as well as its aluminization, as compared with the aegirite of the typical grennaite. The variation in the alkali content lies within the possible limit of variation in grennaite.

Comparing the norm of the marginal facies with that of ordinary grennaite, it is seen that the amount of salic minerals has increased considerably. The marginal facies shows no normative aegirite. The decrease in ferric iron involves an enrichment of normative nepheline in relation to grennaite. We have therefore the reverse relation in quantity between normative albite and nepheline as compared with ordinary grennaite. The normative amount of nepheline corresponds rather well with the actual amount of this mineral.

In the quantitative system the marginal facies of grennaite has the position I : 7 : 1 : 4, Laugenose.

A few centimetres from the boundary the rock becomes darker and at the same time more strongly schistose. The nepheline is completely decomposed into a turbid mass; aegirite does not occur but instead biotite is found and occasionally a grain of amphibole with dark bluish green colours. The turbid alteration product of nepheline has index of refraction below that of kollolite and is probably natrolite. Fresh natrolite, however, is also found, occurring in veins replacing nepheline and feldspar. The biotite occurs in small flakes sometimes terminated by pyramidal faces. It shows strong pleochroism with X: pale yellowish brown, almost colourless; Y: dark reddish brown, and Z: dark brown, almost opaque. The feldspar is unaltered and has the same appearance as in ordinary grennaite. Fluorite is occasionally seen, forming streaks running in a direction parallel to the schistosity.

f. Pegmatitic Schlieren of Grennaitic Composition.

In some places rock types of medium- to coarse-grained texture have been found, which, but for the feldspars, contain the same minerals as grennaite but in different proportions. They stand in evident genetical connection with this rock. They occur as vein- and lens-like segregations of different sizes, from small veins of a few centimetres width to large lenses more than three metres in length. Only a few of the schlieren are so coarse-grained that they deserve the term pegmatite. In general the grain size is not more than 5 mm, so that the rocks are actually only medium-grained and *sensu strictu* no pegmatites. However, owing to the relative coarseness of grain as compared with grennaite, the schlieren give in the field the impression of having a pegmatitic development. Further, their mode of occurrence in grennaite is analogous to that of pegmatitic schlieren in granite and they remind one very much of these.

Törnebohm was only aware of one occurrence of these rocks. It is situated on the top of a small hill and is exposed only in horizontal section. This has an oval form and occupies a few square metres. Törnebohm advanced the opinion (1906, p. 34) that this occurrence represented an eruption channel. Other occurrences of similiar rocks have proved, however, to be closed bodies and a blast on the side of the occurrence in question showed that it became more narrow at a deeper level.

The hypothesis of Törnebohm must therefore be rejected. As another alternative Törnebohm proposed that the rock had crystallized in a deep-seated section of the earth and had been brought to its present position by the eruption of a grennaite magma (katapleite syenite magma in the sense of Törnebohm). In the opinion of the writer this hypothesis must also be rejected. The mode of occurrence of these rocks strongly suggest that they crystallized *in situ*. Probably they are local crystallization products, the coarse-grained texture of which may be due to an accumulation of gases and solutions, which allowed the formation of larger crystals.

The rocks from different occurrences of schlieren and even within the same occurrence may show considerable variation in mineral distribution, but never so much that they cannot be regarded as varieties of the same kind of rocks. Most varieties can be characterized either as leucocratic or as melanocratic as compared with grennaite. The petrographical characteristics of the different varieties are best described in connection with the respective occurrences.

Occurrence 1: Törnebohm has given a rather thorough description of the rock from the one occurrence of which he was aware. It is situated some 400 metres from the northern end of the district and in the central part of it. Here the rock is in the main equigranular and medium-grained with a grain size of about 4 mm. The mineral components aegirite, nepheline, microcline, eudialyte and katapleite can be recognized megascopically. The black aegirite and the rose coloured eudialyte are most distinctive. Nepheline has a greasy lustre and sometimes a pale reddish colour and is therefore easily distinguished from the colourless microcline. Katapleite is present in much smaller quantity than eudialyte and generally occurs in smaller grains. These grains are light reddish brown. Aegirite and also eudialyte are seen to be far more abundant than in grennaite.

In the microscope it is seen that aegirite generally occurs in isolated individuals, in part euhedral in the prismatic zone and sometimes also terminated by pyramidal faces, in part anhedral and with fringed boundaries. Sometimes several aegirite individuals have gathered to form aggregates.

Nepheline shows no signs of crystallographic development. It has numerous inclusions of microcline and sometimes albite. The nepheline is generally fresh but sometimes parts of it are decomposed into a turbid mass with index of refraction higher than kollolite, probably being of micaceous composition. It very much resembles the gieseckite pseudomorphs as described by Ussing (1898, p. 121) from Akuliarusek, and by Quensel (1914, p. 169) from Almunge.

Microcline is anhedral like the nepheline. It has sometimes inclusions of albite. Independent albite individuals are only rarely found and are then strongly corroded by microcline.

Eudialyte is most often irregularly bounded but may show a subhedral development. It has sometimes inclusions of katapleite. Katapleite is the only component of this rock with a distinct euhedral development. The katapleite crystals have the form of large laths sometimes a little resorbed by microcline and nepheline. They are often broken up into several parts and may be more or less crushed, but even then the original boundaries of the crystals are usually recognizable.

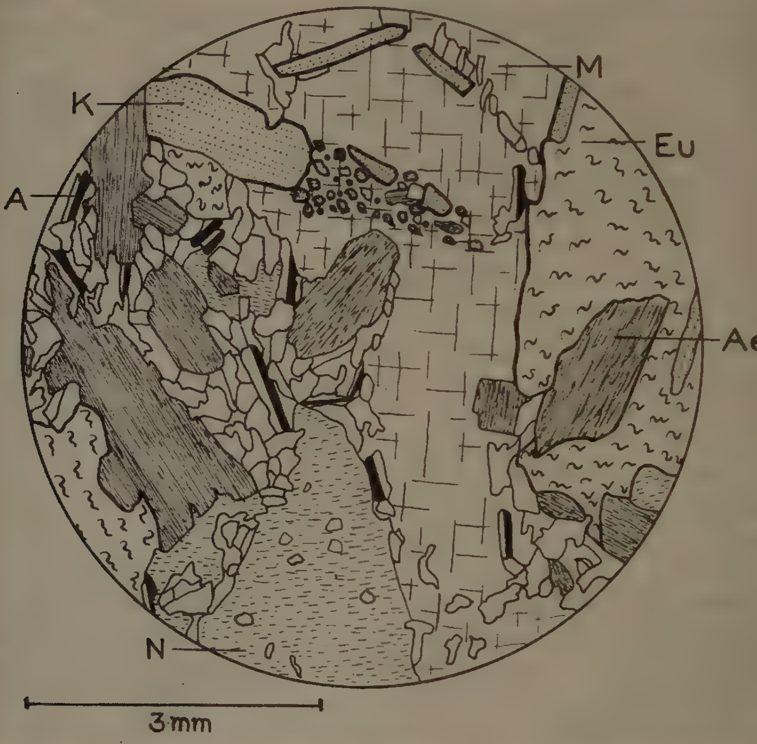

Fig. 12. Pegmatitic schlieren in grennaite. Melanocratic type. Occurrence 1. (Analysis in Table 16.)
A: albite, M: microcline, N: nepheline, Ae: aeg rite, K: katapleite, Eu: Eudialyte.
Magnification: c. 13.

The texture has a somewhat cataclastic character indicated by the just mentioned deformation of the katapleite crystals and by granulated zones which consist of fragments of the larger individuals, especially microcline. In these zones natrolite is sometimes seen as the latest crystallization product. Natrolite also often replaces microcline and nepheline in the way described under grennaite.

The texture of the rock shows no definite order of crystallization as is the case for pegmatites in general. Certain regularities can nevertheless be observed: aegirite shows an inclination to crystallize before microcline and nepheline, and albite seems always to have crystallized after microcline. Katapleite has solidified at an early stage in the history of the crystallization (Fig. 12).

The analysis of this rock (Table 16) will be discussed on p. 163.

On the slope of the small hill where Törnebohm's occurrence is situated the writer found two lens-like segregations with a maximum diameter of about half a metre. They had a more coarse-grained texture than the rock of the occurrence just described, but the mineral composition was the same. Characteristic of this variety is a light blue katapleite and a rose coloured nepheline giving the rock a remarkably beautiful appearance. Up to 30 metres distance from this locality the grennaite contains small veins and decimetre-long schlieren consisting of similiar rocks but generally containing less katapleite and eudialyte.

Occurrence 2: This is situated some 250 metres from the Norra Kärr farm in a southwesterly direction. In the side of a small outcrop, three metres high and twenty metres long, a group of horizontal schlieren of magnitudes varying from a few centimetres to about three metres extension are exposed. The genetical relationship between the schlieren and the grennaite is particularly well demonstrated at this locality. The schlieren are subparallelly arranged, the direction of elongation following the schistosity of the grennaite. The structure of the grennaite follows the shape of the schlieren, which have a certain influence upon the mechanical properties of the grennaite. Generally it is difficult to obtain a hand specimen of grennaite because the rock is hard and dense and shows no preferential cleavage direction. The grennaite in contact with the schlieren will, however, separate in plate-like specimens even on moderate hammering.

This occurrence shows two main types of rocks. One type has a composition so similar to that of the rock from Occurrence 1, that they can be regarded as two varieties of the same type of rock. As mentioned above, this type, as compared with grennaite, is far more rich in aegirite. In the other type aegirite occurs only as a subordinate mineral and sometimes the rock is quite devoid of it. Thus compared with grennaite the one type may be said to be melanocratic and the other leucocratic. Common to both is an enrichment of zirconium. In those schlieren which are exposed the leucocratic type is quantitatively dominant. In the largest schlieren of about three metres length both types are present. Each type occupies one end of the schlieren and there is gradual transition between them.

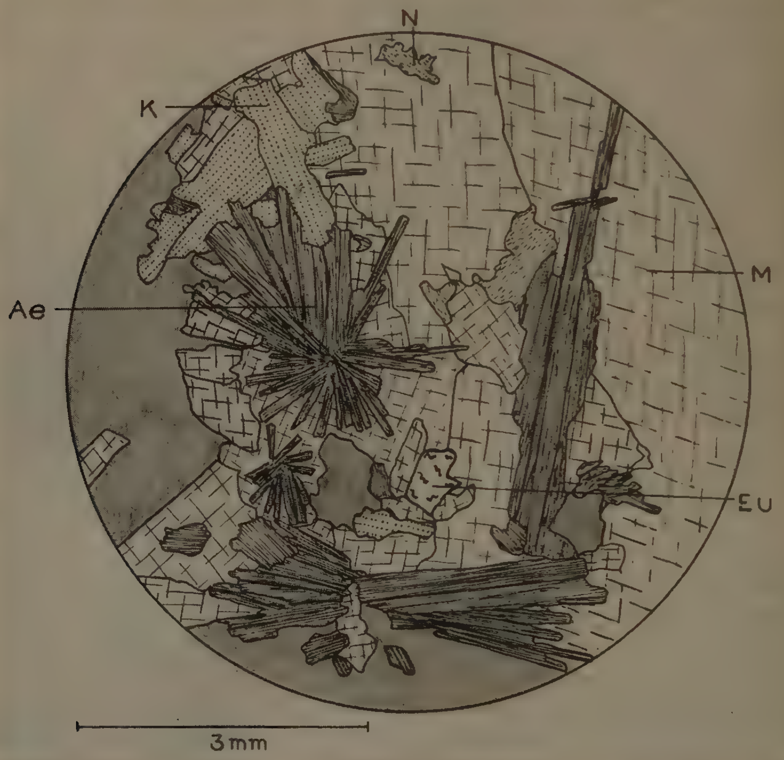

Fig. 13. Pegmatitic schlieren in grennaite. Melanocratic type. Occurrence 2. M: microcline, N: nepheline, Ae: aegirite, K: katapleite, Eu: eudialyte. Gray is kollolite. Magnification: c. 13.

The main minerals of the melanocratic type are microcline and aegirite. The melanocratic schlieren show, however, varying amounts of nepheline. In some schlieren the rock will be rich in nepheline, while in the adjacent ones it may be almost absent. The rock is rich in katapleite, while eudialyte is not so abundant (Fig. 13).

Microcline occurs in individuals of about five mm diameter, sometimes larger. Aegirite generally forms asteroid or sheaflike aggregates of about five mm size, but is also found in single individuals, which are then larger than the individuals composing the aggregates. Natrolite mostly occurs interstitially between the other minerals in the form of aggregates. However, natrolite veins often run into microcline individuals and resorb them. These veins generally have a natrolite aggregate as a base. The natrolite veins are turbid as are in part, the aggregates. Katapleite is most often developed in prisms of three—four mm length, but may occasionally show anhedral forms. Eudialyte is always anhedral.

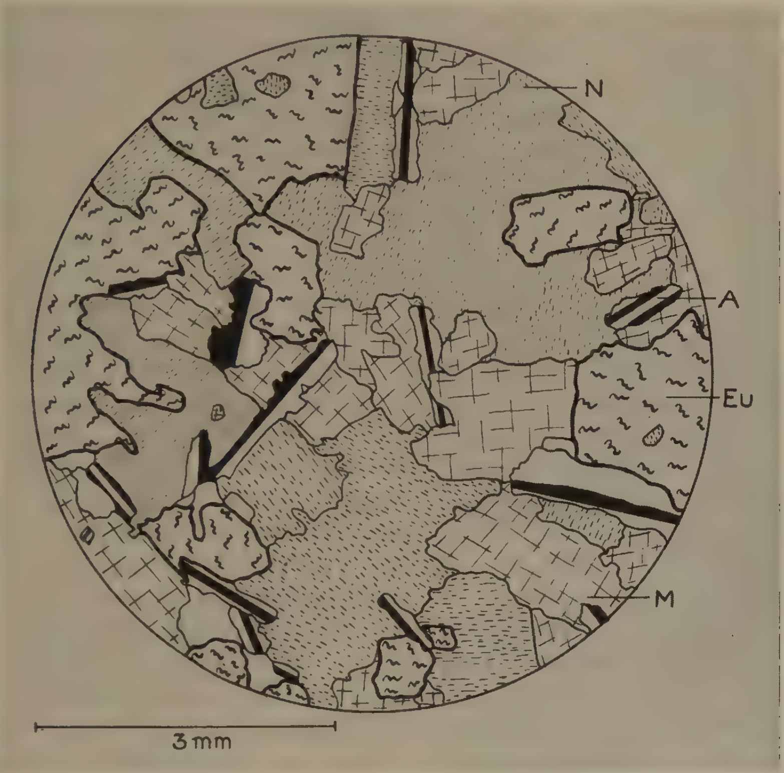

Fig. 14. Pegmatitic schlieren in grennaite. Leucocratic type. Occurrence 2. (Analysis in Table 17.) A: albite, M: microcline, N: nepheline, Eu: eudialyte. Magnification: c. 13.

A definite sequence of crystallization cannot be established. It can only be said that aegirite and katapleite show a tendency to crystallize before the other minerals and that natrolite has been the last mineral to crystallize.

The main minerals of the leucocratic type are microcline, nepheline and eudialyte. These minerals are equigranular with an average grain size of about four mm. Microcline and nepheline are quite anhedral but eudialyte may show a slight tendency to idiomorphism. No definite order of crystallization can be observed between the main minerals (Fig. 14).

The subordinate minerals are albite, aegirite and katapleite. Albite is rather regularly distributed throughout the rock. It occurs in laths of one to two mm length, twinned after the albite law. The individuals are generally found as inclusions in nepheline and microcline, but also occur interstitially between the main components. Albite is much corroded by microcline, but has retained its original habit when bordered by nepheline. An albite lath sometimes extends from one nepheline individual into another or into a microcline individual. In the latter case that part surrounded by nepheline shows strong idiomorphism, whereas the other part is more or less resorbed, often to such an extent that parts of it are detached from the main crystal. The aegirite grains are of 0.5—1.0 mm size, sometimes quite anhedral and sometimes with rather well developed prism faces. They are occasionally found as inclusions in eudialyte. Katapleite occurs rather irregularly. It forms broad prims of one or two mm length, two or three prisms generally being in company.

In summing up the characteristics of the two rock types of this occurrence one may say: Microcline is an important mineral in both rock types. In the leucocratic type nepheline is the dominant mineral, whereas it occurs in varying amounts in the melanocratic type. In the leucocratic rock aegirite is only found occasionally and in small grains. In the melanocratic rock aegirite is a principal mineral and occurs in grains of the same size as microcline and eudialyte. Both the absolute and the relative amounts of eudialyte and katapleite vary in both rock types. Eudialyte is the more abundant of these two minerals, but there seems to be an enrichment of katapleite in the melanocratic type. In the leucocratic type albite is rather common but in the melanocratic type it is rarely found.

Occurrence 3: In the southeastern corner of the district the grennaite is penetrated by a multitude of small schlieren, the largest not more than two decimetres long. They consist essentially of aegirite, microcline and nepheline, the latter altered into a turbid material with higher index of refraction than kollolite, probably being gieseckite pseudomorphs. Katapleite and eudialyte are also present but to a much smaller extent than in the occurrences previously described. A very characteristic constituent of this occurrence is a colourless or pale brownish mineral aggregate which has been determined to be prehnite.

Microcline occurs in somewhat elongated individuals of about five mm size. They are in part euhedrally bounded by nepheline. The nepheline pseudomorphs are quite anhedral. They are also generally elongated with the longest axis parallel to the elongation of the schlieren. Most nepheline pseudomorphs have small inclusions of microcline which are perfectly fresh, like the independent microcline individuals.

Aegirite and katapleite occur in isolated individuals of three to four mm length, generally euhedral after the prism zone. Eudialyte is quite anhedral and forms grains of one or two mm diameter. Albite occurs as a subordinate constituent, most often enclosed in microcline and corroded by this mineral. Natrolite is found only occasionally and then with the same mode of occurrence as already described in the first and second occurrences. Prehnite is seen to replace the nepheline pseudomorphs and sometimes also katapleite. Prehnite in its turn is partly replaced by natrolite. The prehnite aggregates occur on the border between grennaite and the schlieren. They are seen to grow, with the grennaite as a base, into the schlieren.

One of the schlieren at this occurrence is different from the others. It consists mainly of centimetre-large gieseckite pseudomorphs after nepheline dotted with clusters of aegirite. The gieseckite pseudomorphs have megascopically a pure white colour which, being spotted with black aegirite and coloured eudialyte, give the rock a conspicuous appearance. Eudialyte is found in grains of three to four mm size, sometimes with a core of katapleite and with aegirite inclusions. Independent katapleite crystals were not observed. Microcline occurs in somewhat smaller amounts than eudialyte, in two to three mm large individuals, quite anhedral like the gieseckite pseudomorphs. The microcline often has more or less corroded inclusions of albite laths, one to two mm long and consisting of a couple of albite twins. The albite laths may also occur in aggregates.

Occurrence 4: This is situated on the western side of the road from Norra Kärr to Lakarp, some fifty metres from Occurrence 1 in a westerly direction. The schlieren are here mostly some decimetres long. Most schlieren consist mainly of gieseckite pseudomorphs of nepheline and katapleite whereas others contain much aegirite and microcline and sometimes albite aggregates.

The katapleite of this occurrence has a brick red colour as distinct from katapleite in general which is brownish red, except in one occurrence where it is light bluish. Under the microscope it is seen that the katapleite is pigmented with reddish spots. The peculiar colour is due to a decomposition of the katapleite, probably producing some variety of iron oxide or hydroxide.

Boulders: In some of the ditches through the bogs of the southern part of the district, boulders of some decimetres diameter are found, which have been exposed during the digging of the ditches. They have probably been brought up from the underlying bed-rock by the seasonal thawing. Most of the boulders have very much the same appearance as many of the schlieren, but some of them are considerably more coarse-grained than any of the schlieren found in solid rock. The boulders may have microcline crystals of five to seven centimetres magnitude and nepheline individuals of almost the same size. Katapleite occurs in perfectly euhedral crystals of one to two centimetres length, and eudialyte is found in anhedral grains of about one centimetre diameter.

As seen from the above descriptions, grennaite and the pegmatitic schlieren are in the main constituted of the same minerals, nepheline, aegirite, katapleite, eudialyte and natrolite being common to both. The feldspars are, however, different, grennaite containing anorthoclase whereas the pegmatitic schlieren contain microcline and albite. The minerals of the schlieren show some peculiarities not observed in grennaite e. g. decomposition of the nepheline into gieseckite pseudomorphs and different katapleite varieties. Together with the description of the feldspars, a complementary description of the other minerals will therefore be given.

Microcline is the most essential mineral of the pegmatitic schlieren. The larger individuals may be in part crystallographically bounded, whereas the smaller ones are developed as anhedral grains. Under the microscope no difference can be seen between the microcline from different occurrences as to their general appearance. They all have the same characteristic crosshatched twinning texture, more or less regularly developed. The microcline is perfectly homogeneous. Not even with the highest magnification can any signs of perthitic texture be detected. Microcline from different occurrences may show slight variation in optical properties. A specimen from Occurrence 1 had the following indices of refraction:

α: 1.519
β: 1.523
γ: 1.526

and an axial angle $2V\alpha = 65°$.

An alkali determination on this microcline, which had sp. gr. 2.57, was carried out by R. Mauzelius with the result:

K_2O	12.32	Weight %
Na_2O	3.12	»

This corresponds to 73.0 % Kf and 26.5 Naf, thus representing a very pure alkali feldspar.

Table 13.

	1 Weight %	2 Weight %
SiO_2	63.74	64.72
Al_2O_3	18.25	18.35
Fe_2O_3	0.36	
MgO	0.11	
CaO	0.09	
BaO	0.00	
Na_2O	0.77	
K_2O [1]	16.19	16.93
Li_2O	0.00	
Rb_2O	0.3	
Cs_2O	< 0.1	
H_2O	0.05	
	99.86	100.00

1. Microcline from pegmatitic schlieren. Norra Kärr. Analyst: Naima Sahlbom, 1925.
2. Theoretical composition of pure potash feldspar.

A microcline specimen collected by Nils Zenzén during a visit to Norra Kärr has been analyzed by Naima Sahlbom (Table 13). The material on which the analysis was made consisted of pieces about five centimetres large, very like the microcline from the boulders just mentioned. The analysis corresponds to some 93 % Kf, some 6 % Naf and 1 % Rbf, thus being a very pure potash feldspar. The indices of refraction were:

$$\alpha\colon 1.518$$
$$\beta\colon 1.522$$
$$\gamma\colon 1.525$$

and the axial angle $2V\alpha = 65°$.

Albite occurs as a subordinate constituent in most of the pegmatitic segregations. Only in the leucocratic type at Occurrence 2 is it found in greater amount. It is always quite fresh. Generally it has the form of long laths consisting of a couple of albite twins. In Occurrence 1, however, many of the albite grains are untwinned. In contact with microcline it is seen to be severely corroded by this mineral. None of the other minerals have had any corroding effect upon it. The indices of refraction and the extinction angles indicate a very pure albite. The optical properties were found to be:

$$\alpha\colon 1.529$$
$$\beta\colon 1.533$$
$$\gamma\colon 1.539$$
$$2V\gamma = 80°.$$

The extinction angle in the symmetrical zone was 17°.

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[1] The determinations of Li_2O, Rb_2O and Cs_2O have been carried out at the Geochemical Laboratory of the Boliden Mining Company. The figures for these determinations have been deducted from the original K_2O value 16.49.

Nepheline occurs partly fresh and partly decomposed. It shows various colours from light gray to reddish. Generally nepheline does not show any kind of crystallographic development. In some of the boulders, however, almost completely decomposed nepheline individuals with distinct crystal forms have been observed. The indices of refraction of the fresh nepheline were:

$$\omega\colon 1.534$$
$$\varepsilon\colon 1.530.$$

The differences between these figures and those of the nepheline belonging to the grennaite lie within the limit of error of the immersion method.

The nepheline pseudomorphs have megascopically a white colour. Under the microscope they are seen to consist of a light brown, turbid material with medium index of refraction 1.590. As mentioned above it is probably identical with the gieseckite pseudomorphs (Ussing 1898, p. 121).

Aegirite from different occurrences shows the same optical properties, which are almost identical with those of aegirite from grennaite.

$$X \wedge c = 2\text{—}3^\circ$$
$$2V\alpha = 60^\circ.$$

X: brownish green, Y: yellowish green, Z: yellowish green.

$$X > Y \geqq Z.$$

Dispersion is distinct $r > v$. Twinning after (100) is rather common, particularly in the large aegirite individuals of the melanocratic type. The aegirite of the pegmatitic schlieren is always dark green, whereas the aegirite of grennaite has a much lighter green colour.

Eudialyte has in general entirely anhedral forms. Megascopically it has a bright rose colour, giving a conspicuous appearance to the rock containing it. Under the microscope it is however colourless. The extinction is most often not uniform, generally showing some kind of zonal structure. Some individuals may have a core of katapleite. All grains of which it has been possible to obtain a suitable interference figure have shown an optically positive character. The indices of refraction are exactly the same as those for the eudialyte belonging to grennaite:

$$\omega\colon 1.617$$
$$\varepsilon\colon 1.621.$$

Katapleite in most occurrences has a brownish red colour. Only in one occurrence is it light bluish. Both varieties show quite the same habit, forming centimetre-large euhedral individuals bounded by prismatic and pyramidal faces. Under the microscope no difference can

Table 14

	1	2	3	4	5
SiO_2	44.20	43.69	43.14	43.92	44.70
ZrO_2	31.82	32.00	29.16	30.80	30.85
Al_2O_3	—	—	0.79	—	
FeO	0.22	0.27	0.17	0.10	0.71
CaO	5.31	3.12	2.26	0.81	
Na_2O	8.93	12.62	13.59	15.05	14.09
K_2O		0.24	0.14		
H_2O	9.26	8.63	10.75[1]	9.24	9.07
	99.74	100.57	100.00	99.92	99.42
		Sp. gr. 2.790			Sp. gr. 2.781

1. Lime-soda katapleite. Langesundsfjord. Brögger, 1890, p. 456. Analyst: Weibull.
2. Brownish red katapleite. Norra Kärr. Törnebohm, 1906, p. 18. Analyst: R. Mauzelius.
3. Light bluish katapleite. Norra Kärr. Analyst: A. Bygdén, 1943.
4. Soda katapleite. Langesundsfjord. Brögger, 1890, p. 456. Analyst: Cleve.
5. Katapleite. Narsarsuk, Greenland. G. Flink, 1899, p. 102. Analyst: G. Flink.

be seen between the two varieties. They give the same beautiful interference figure as the katapleite phenocrysts of the grennaite, previously described.

In contrast to the phenocrysts they are remarkably free from inclusions. The brownish red variety has the same indices of refraction as the katapleite of the grennaite $\alpha \sim \beta$: 1.585 and γ: 1.603, whereas the light bluish variety shows slightly lower figures $\alpha \sim \beta$: 1.582 and γ: 1.600. The brownish red variety is probably nearly identical with the katapleite of the grennaite which had a grayish white colour. This colour may, however, be due to the abundance of feldspar and nepheline nclusions in the phenocrysts.

Brögger (1890, pp. 435, 456) distinguished two kinds of katapleite rom Langesundsfjord: lime-soda katapleite and soda katapleite. The ormer had yellow brown to reddish colours and the latter was bluish. The two varieties from Norra Kärr are in appearance very similiar to he corresponding varieties from Langesundsfjord. In Table 14 two epresentative analyses of the katapleite varieties from Langesundsfjord are given together with the two analyses available of the varieties rom Norra Kärr. For comparision an analysis of katapleite from Greenland is added. It is seen that the varieties from Norra Kärr occupy an intermediate position between the varieties from Langesundsfjord.

Under the description of Occurrence 4 it was mentioned that the atapleite here had a brick red colour and that under the microscope was seen to be pigmented with reddish spots. The colour of the pig-

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[1] H_2O has not been determined. The figure given is derived by difference.

Table 15.

	1	2
SiO_2	43.44	43.69
ZrO_2	26.98	32.00
Al_2O_3	2.89	—
FeO	0.55	0.27
CaO	8.47	3.12
Na_2O	6.49	12.62
K_2O	0.10	0.24
H_2O	11.08[1]	8.63
	100.00	100.57

1. Decomposed brick red katapleite, Norra Kärr. Analyst: A. Bygdén, 1943.
2. Brownish red katapleite. Norra Kärr. Törnebohm, 1906, p. 18. Analyst: R. Mauzelius.

ment material indicates that it is an iron compound. It may be that the original content of iron in katapleite has separated to form a new mineral phase. The brick red katapleite has the same habit as the two varieties of katapleite already described and megascopically it only differs from these in colour. The analysis of the brick red katapleite is compared with the ordinary brownish red katapleite in Table 15. The main difference is seen to be the ratio between lime and sodium. There is, however, no evidence that the variation in this ratio is the result of alteration processes. It is quite possible that there was a primary difference in the content of lime and sodium in the two katapleite specimens. In that case the brick red katapleite represents a variety of lime-soda katapleite even richer than Brögger's original type.

Natrolite is present in a considerably varying amount in different specimens, even within the same occurrence. It is the most irregularly distributed mineral of the pegmatitic schlieren. It has the same mode of occurrence as in grennaite, partly occurring interstitially between previously crystallized minerals, partly replacing microcline and nepheline. Natrolite is generally fresh but sometimes it is more or less turbid, especially when it has the last mentioned mode of occurrence. The optical properties are the same as for natrolite belonging to grennaite:

$$\alpha: 1.478$$
$$\beta: 1.483$$
$$\gamma: 1.492$$
$$2V\gamma = 60°.$$

The dispersion is weak $r < v$.

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[1] H_2O has not been determined. The figure given is derived by difference.

Table 16.

Analysis of pegmatitic schlieren in grennaite. Melanocratic type. Norra Kärr.

Analyst: R. Blix, 1943.

	Weight %	10 000 M	Norm		Mode, Vol %		Niggli's system	
SiO_2	52.82	8 759	Or	25.23	Microcline		qz	: 102
TiO_2	0.08	10	Ab	24.67	$Kf_{73}Naf_{27}$	35	si	166
ZrO_2	2.52	205	Nef.	25.20	Albite	5	ti	0.19
Al_2O_3	18.46	1 806	Hl.	0.07	Nepheline	30	zr	3.90
Fe_2O_3	6.22	390	Z	3.75	Aegirite	15		
FeO	1.19	166			Eudialyte	5	al	34.4
MnO	0.26	37	Σ sal	78.92	Katapleite	10	fm	19.3
MgO	0.13	32	wo	2.51			c	4.1
CaO	1.21	216	en	0.32		100	alk	42.2
BaO	trace		ac	9.30				
Na_2O	10.95	1 766	Na_2SiO_3	2.52			mg	0.03
K_2O	4.26	452	il.	0.15			k	0.20
P_2O_5	0.00		mt	4.37				
$H_2O > 105°$	1.52		pr	0.06			c/fm	0.21
$H_2O < 105°$	0.22							
F	0.00		Σ fem.	19.23				
Cl	0.04		H_2O	1.74				
S	0.03							
	99.91			99 89				
Less O for Cl, S	0.02							
	99.89							

Quantitative System: II : 6 : 1 : 4, Lardalose.

Prehnite is found only in Occurrence 3, and here it occurs as an auxiliary constituent. It forms four to five mm large, fanlike aggregates which are built up of rectangular lamellae radiating from a centre. It has intense blue anomalous interference colours. The extinction is very irregular, showing the typical and peculiar characteristics of this mineral. The optical properties are:

α: 1.613
β: 1.623
γ: 1.642
$2V\gamma = 65°$.

Dispersion is weak $r > v$. It has positive elongation.

Chemical analyses of the two most important types of pegmatitic rocks have been made, that from Occurrence 1 (Table 16) and the predominant type in Occurrence 2 (Table 17). As compared with grennaite the first one can be characterized as melanocratic and the second as leucocratic, as has been pointed out previously. Both analyses show the characteristic features of grennaite, high content of sodium and

Table 17.

Analysis of pegmatitic schlieren in grennaite. Leucocratic type. Norra Kärr.

Analyst: Thelma Berggren, 1942.

	Weight %	10 000 M	Norm		Mode Vol%		Niggli's system	
SiO_2	52.60	8 723	Or	34.33	Microcline		qz	: 96
TiO_2	0.03	4	Ab	19.91	$(Kf_{73}Naf_{27})$	40	si	177
ZrO_2	1.95	159	An	2.79	Albite	7	ti	0.08
ΣY_2O_3 [1]	0.52	21	Nef	29.41	Nepheline	33	zr	3.86
ΣCe_2O_3 [1]	0.33	10	Hl	0.11	Aegirite	2		
Al_2O_3	21.73	2 126	Z[2]	3.95	Eudialyte	12	al	45.1
Fe_2O_3	0.50	31	Σsal	90.50	Katapleite	3	fm	6.3
FeO	0.76	106			Natrolite	3	c	5.4
MnO	0.31	44	wo	1.62		100	alk	43.2
MgO	0.33	82	en	0.58				
CaO	1.42	253	fs	1.07			mg	0.28
SrO	0.022	2	fo	0.17			k	0.30
BaO	0.00		fa	0.35				
Na_2O	8.80	1 419	il	0.06			c/fm	0.12
K_2O	5.79	615	mt	0.72				
P_2O_5	< 0.01		fl	0.15				
SO_3	0.00		Σfem	4.72				
$H_2O > 105°$	4.40							
$H_3O < 105°$	0.40		H_2O	4.80				
F	0.06	32		100.02				
Cl	0.06	17						
	100.01							
Less O for F, Cl	0.04							
	99.97							

Quantitative System: I : 6 : 1 : 4, Miaskose.

1. La_2O_3 0.044; Ce_2O_3 0.129; Pr_2O_3 0.017; Nd_2O_3 0.113; Sm_2O_3 0.027; Eu_2O_3 0.004; (ΣCe_2O_3 0.33); Gd_2O_3 0.028; ThO_2 0.004; Tb_2O_3 0.008; Dy_2O_3 0.044; Y_2O_3 0.409; Ho_2O_3 0.004; Er_2O_3 0.020; Tu_2O_3 0.004; Yb_2O_3 0.015; Cp_2O_3 0.004; (ΣY_2O_3 0.52).
2. The lanthanides are included with ZrO_2 in the calculation of normative zircon.

zirconium, very small amounts of manganese and magnesium and an insignificant amount of titanium. They differ, however, in iron content, Table 16 showing a considerably higher amount of iron, whereas Table 17 shows a much smaller amount than in grennaite. Among themselves the main difference is also the iron content. The lanthanides were only determined in the leucocratic rock. A lanthanide determination for the melanocratic rock would probably show a much smaller amount, because katapleite here dominates strongly over eudialyte and katapleite seems to be devoid of lanthanides (see Table 7). The determinations (Table 17), which were performed by means of X-ray spectrographical analysis at the Geochemical Laboratory of the Boliden Mining Company, show that there is a somewhat greater amount of yttrium lanthanides than of cerium lanthanides.

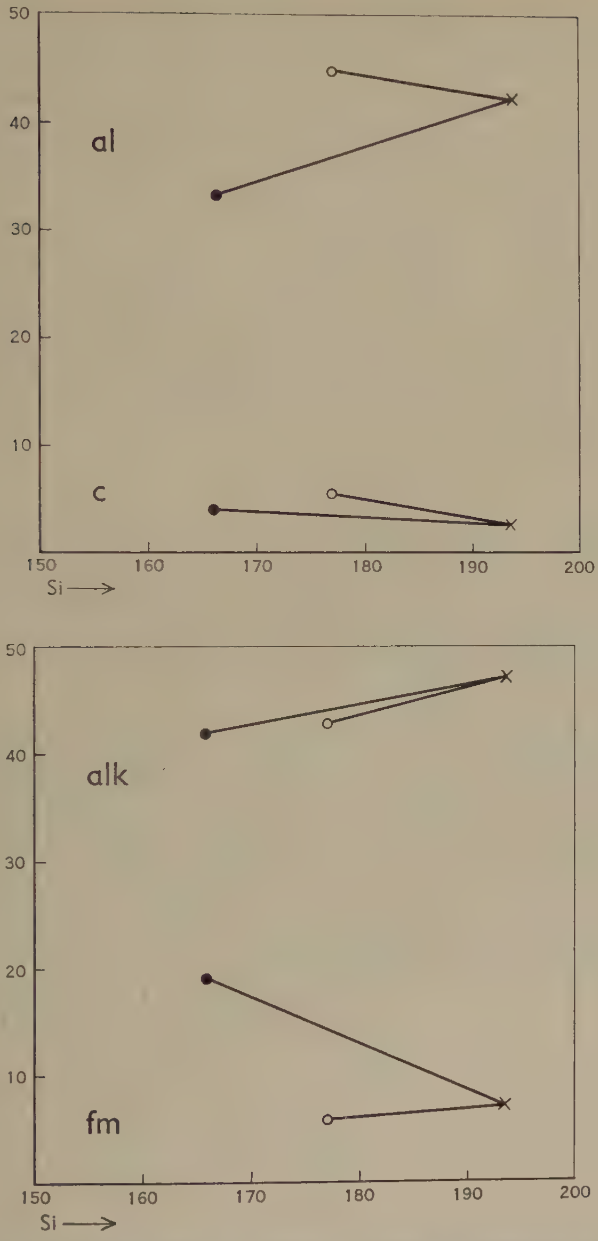

Fig. 15. Niggli diagrams showing the variation between grennaite and the pegmatitic schlieren in grennaite. Grennaite is represented by a cross, the leucocratic schlieren by an open circle and the melanocratic schlieren by a solid circle.

Comparing the norms of the two analyses, it is seen that the melanocratic rock has a more alkaline character than the leucocratic, containing normative sodium metasilicate, whereas the leucocratic has sufficient aluminium to form normative anorthite. The melanocratic rock is even more alkaline than grennaite, falling into Ussing's agpaite subgroup of the nepheline syenite family (see p. 180).

In the quantitative system the melanocratic rock has the position II : 6 : 1 : 4, Lardalose, whereas the leucocratic rock has the same position as grennaite I : 6 : 1 : 4, Miaskose.

The variations in chemical composition between grennaite and the pegmatitic schlieren are demonstrated in the Niggli diagrams in Fig. 15. It is seen that the melanocratic rock shows a decrease in *al* and an increase in *fm* as compared with grennaite, whereas the leucocratic rock shows an increase in *al* and a decrease in *fm*. *c* and *alk* show only slight variation.

Some 20 metres north of the Norra Kärr district, some decimetre-large boulders of a white sugar-grained rock, consisting essentially of feldspar and with some amphibole, are found. The grain size is about 0.2 mm. The boulders have undoubtedly belonged to the Norra Kärr district. Even after a thorough search it was not possible to find this rock in place.

Under the microscope the rock is seen to consist essentially of albite, a great part of which is untwinned. The medium index of refraction is somewhat lower than that of kollolite, 1.534, indicating almost pure albite. Microcline with characteristic grating texture occurs in subordinate amounts. Amphibole is somewhat more abundant. It occurs as aggregates arranged in parallel zones of a few mm width and at intervals of some centimetres. A few grains of fluorite can also be observed. The optical properties of the amphibole are:

$$Y = b, \quad X \wedge c = 14^\circ$$

$$2V\gamma = 60^\circ$$

X: bluish green, Y: bluish green, Z: pale yellowish green

$$X = Y > Z$$

$$\beta: 1.652 \pm 0.005$$

$$\gamma - \alpha = 0.006.$$

Dispersion is strong $r > v$.

The extinction angle and the pleochroism indicate an alkali amphibole. It is, however, not identical with any of the other alkali amphiboles from the Norra Kärr district, to be described later on. The positive optical character of the mineral is worthy of mention, most alkali amphiboles being negative. Some riebeckites are, however, positive. The amphibole resembles riebeckite also in its low double refraction. The extinction angle is, however, greater than that reported for any riebeckite and the indices of refraction much smaller.

B. Enclosed Rocks.

Different kinds of rocks occur as inclusions in grennaite. Common to all of them, in contrast to grennaite, is a phanerocrystalline texture. They have been observed at eleven localities, covering an area of less than one tenth of the Norra Kärr district. Though they occupy only a subordinate part of the district, they are of as great an interest as the main rock, and are of especial importance in the genetical interpretation of the district.

The phanerocrystalline rocks occur in separated areas, most of them situated along the border of the district, particularly in its northwestern part. They are all elongated in a north-south direction, having the form of narrow or broad ovals. They are of various sizes, from some 5 metres to about 150 metres in length. The main areas are sometimes followed by small bodies of two or three decimetres diameter occurring in the immediate neighbourhood of the main area and consisting of the same rock. The contact relations of the enclosed areas with the surrounding grennaite indicate that the phanerocrystalline rocks are older than grennaite, the bodies conforming to the direction of foliation in grennaite.

The phanerocrystalline rocks of the Norra Kärr district display considerable variation in chemical and mineralogical composition. Chemical analyses show that they vary from Lardalose over Akerose and Umptekose to Nordmarkose, as expressed in terms of the quantitative system. Petrographically they may be divided into five rocks, three of which belong to one mineralogically well-defined group, which is clearly distinguished from the other two rocks. One of the rocks may be properly referred to as pulaskite, whereas the others cannot be distinguished by petrographical terms now in use. For the sake of convenience the names lakarpite[1] and kaxtorpite were therefore introduced, derived from two farms situated within the Norra Kärr district. According to their zirconium contents the rocks may be classified as follows:

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[1] As mentioned above (p. 121), the term lakarpite has been used in a broader sense by Törnebohm without any petrographical distinction.

I. With low zirconium content, entering into rosenbuschite.
   Lakarpite (arfvedsonite-albite-nepheline-syenite).
   Pulaskite.

II. Zirconium-free or with trifling amounts of zirconium.
   The Kaxtorpite group.
      pectolite-eckermannite-aegirite-nepheline-syenite.
      eckermannite-aegirite-nepheline-syenite.
      eckermannite-aegirite-syenite.

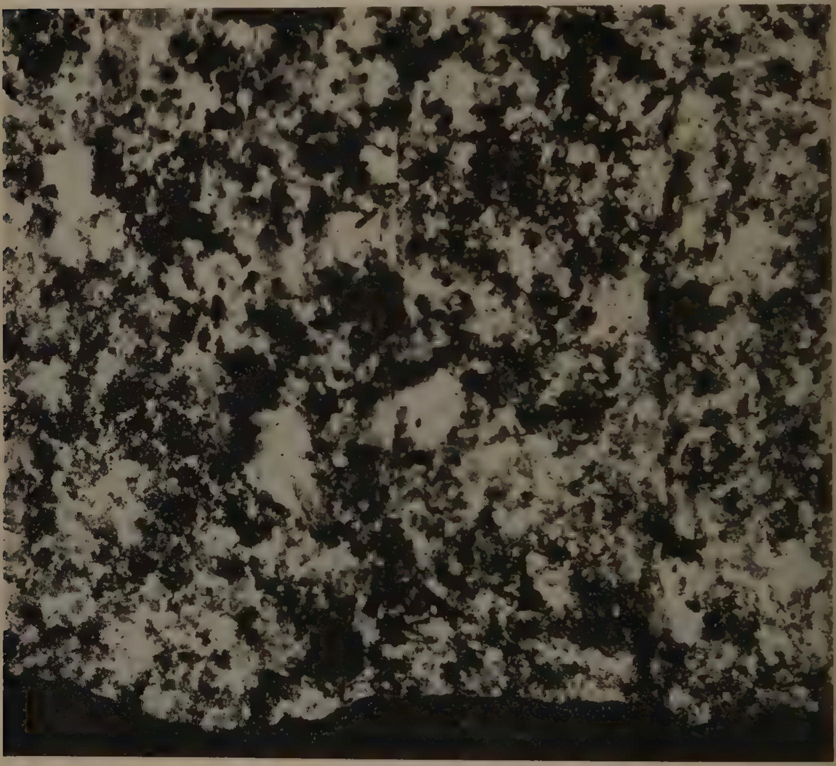

Fig. 16. Massive lakarpite. Aggregates of arfvedsonite appear black. The white areas are essentially albite and nepheline. (Photo S. Hedlund.) Magnification: $1^1/_4$.

The quantitative distribution of the different rocks may be studied in the accompanying map.

1. Lakarpite (arfvedsonite-albite-nepheline-syenite).

Lakarpite is a medium-grained rock with grain size about three mm, consisting essentially of albite, arfvedsonite and nepheline. In smaller amounts the following minerals occur, mentioned in order of their abundance: microcline, rosenbuschite, fluorite, apatite and titanite. In certain varieties two minerals are found as accessories, låvenite and one mineral which has not been definitely identified. Lakarpite occurs in partly massive, partly schistose varieties, the latter showing evidences of cataclastic deformation.

a. Field Observations.

Lakarpite has been found at two localities. The main occurrence is situated on the western side of the road between the farms Lakarp and Norra Kärr, where this road cuts the border between the provinces of Östergötland and Småland. It forms an oval area about 30 metres long and 15 metres wide, showing a well defined contact with the surrounding grennaite. The lakarpite is in the main highly schistose, the schistosity being parallel to the long axis of the lakarpite area which again is parallel to the schistosity of the grennaite. The structure of the lakarpite does not, however, conform with the border. At both ends of the area the structure is seen to be at right angles to the border-line.

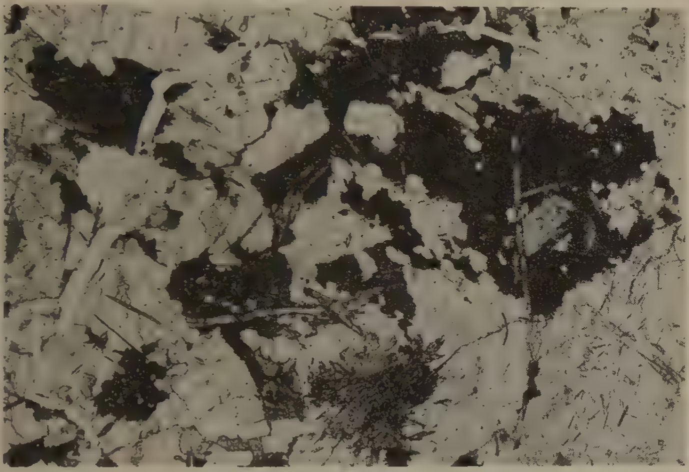

Fig. 17. Massive lakarpite. Black areas are arfvedsonite. White areas are albite and nepheline. The grayish prismatic crystals and radial needles are rosenbuschite. // nicols. Magnification: 10.

The rock type which attracts greatest attention at this locality is a massive lakarpite variety which forms a couple of well rounded, almost circular bodies of 1.5 metres diameter surrounded by the schistose variety. The arfvedsonite shows here a marked tendency to collect in clusters consisting of half a dozen individuals. These arfvedsonite clusters are regularly distributed throughout the rock, giving it a peculiar spotted appearance. The grain size of the massive lakarpite is somewhat larger than that of the schistose variety. In mineral composition the two varieties in no way differ from each other. The relative proportions between the different minerals may, however, show some variation.

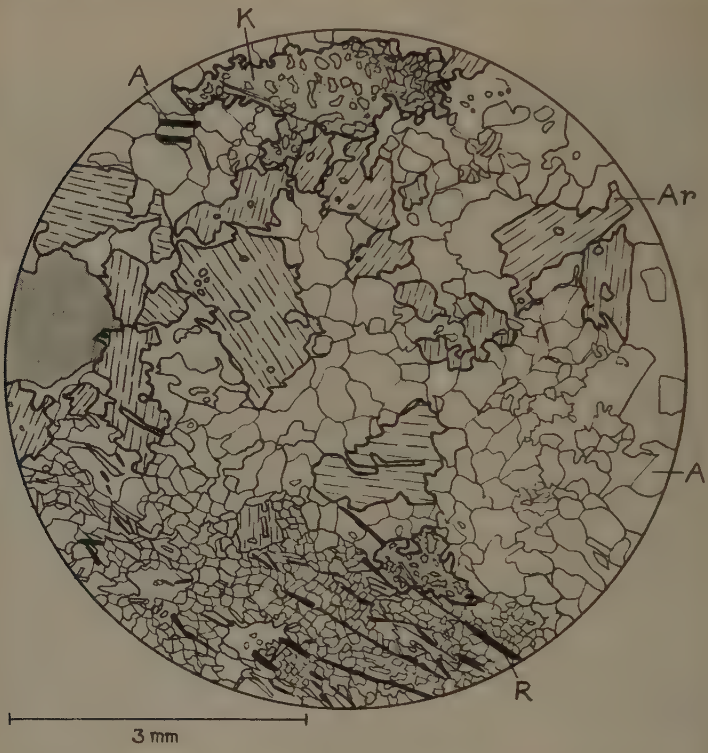

Fig. 18. The border zone of lakarpite, near the contact with grennaite, showing evidence of intermixture with material from the grennaite. A: albite, Ar: arfvedsonite, R: rosenbuschite, K: katapleite. The gray area on the left is a void in the thin section. Magnification: c. 13.

There is in general a smaller amount of arfvedsonite in the schistose variety than in the massive. Both varieties may also among themselves show a good deal of mineralogical variation, particularly in the distribution of nepheline, which often gathers in certain parts of the rock, whereas it is only sparsely represented in others.

In the interspace between the two circular bodies of massive lakarpite occurs a lakarpite variety which sometimes has a porphyritic appearance. Under the microscope it can be seen that the texture is actually pseudoporphyritic and caused by granulated zones of feldspar surrounding some of the albite individuals. The lakarpite is at this place very inhomogeneous. Sometimes accumulations of microcline are seen in certain parts of the lakarpite body. Rosenbuschite is present in almost the same amount as in ordinary lakarpite, whereas arfvedsonite only occurs as an auxiliary constituent. Törnebohm (1906, p. 19) described this rock as forming a dike of about one decimetre's width, reporting that Hamberg had observed it intersecting the massive lakarpite. During the field work I was able to rediscover Hamberg's original locality, but found that the microcline-rich rock had been completely removed by blasting. A fresh blasting at the above mentioned locality, which is situated only a couple of metres from Hamberg's locality, exposed the same rock again. Here, however, it can by no means be regarded as forming a dike, occurring as small areas of a few decimetres' magnitude, connected to the ordinary lakarpite by all kinds of transitional types.

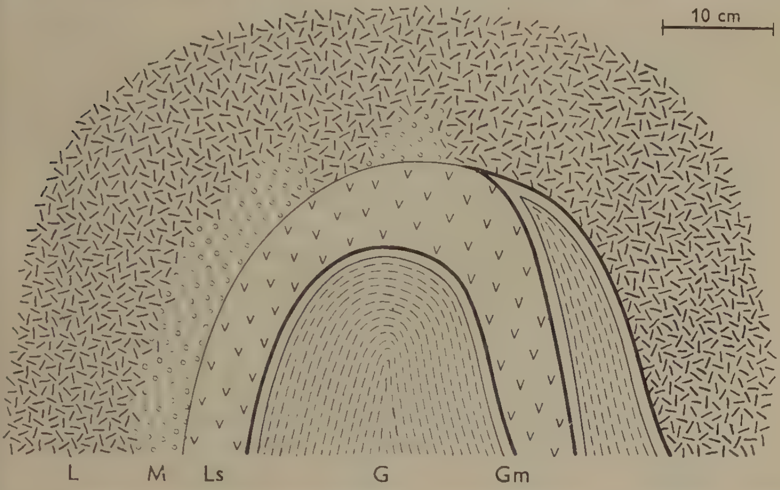

Fig. 19. Contact of grennaite with lakarpite (vertikal section). L: massive lakarpite, Ls: schistose lakarpite, M: accumulations of microcline, G: grennaite, Gm: marginal facies of grennaite.

The structure of grennaite can be seen to follow the circumference of the lakarpite area, indicating that it solidified after the formation of the lakarpite. The lakarpite is more schistose along the border than in the central parts of the lakarpite area, but otherwise no difference between the lakarpite of the margin and that of the centre can be seen megascopically. Under the microscope one can, however, observe grains of katapleite and aegirite in the border zone of the lakarpite body, undoubtedly derived from the grennaite (Fig. 18). Grennaite has in general retained its common appearance up to the very contact. Only at one place are the features different, as can be seen from the accompanying sketch (Fig. 19). The grennaite has here a white marginal zone of about two centimetres width (Gm). Under the microscope it is seen to be devoid of aegirite. The same feature has been observed on a larger scale at the contact of the grennaite with the Växiö granite (see p. 148). The white grennaite zone occurs where the border line describes a curve between the two bodies of massive lakarpite, which are situated near the border in the central part of the lakarpite area.

The contact relations between lakarpite and grennaite point on the whole to the conclusion that lakarpite is older than grennaite. Conclusive evidence, such as grennaite veins intersecting lakarpite, has however not been found. The contact relations at other parts of the border are on the contrary rather dubious. Thus at one place the lakarpite is seen to send apophyse-like projections into grennaite, at first sight giving the impression of being a later crystallization product than grennaite. A closer inspection shows, however, that the structure of the grennaite follows the contact, and a microscopical examination of the contact rock shows that arfvedsonite is substituted to a considerable extent by aegirite. Katapleite and eudialyte are also found here, both minerals alien to the typical lakarpite but characteristic of grennaite. It seems that lakarpite was mobilized before the crystallization of the surrounding rock began, and to such extent that the (with respect to this process) original lakarpite body attained a new configuration under influence from the surrounding rock.

It is worthy of mention that the white marginal zone of grennaite only occurs where the two small bodies of massive lakarpite are situated in the immediate neighbourhood of the border between the lakarpite area and grennaite. It may be that the massive lakarpite has not been mobilized, in contrast to what is supposed for the schistose lakarpite. It is conceivable that the schistose lakarpite was so heated before the crystallization of the surrounding rock that it allowed a great deal of assimilation to take place of all components of the grennaite, whereas near the massive lakarpite the grennaite crystallized more rapidly, promoting the development of a marginal facies of grennaite similiar to that occurring at the boundary with the granite (see p. 148).

The contact relations cannot be studied at the second occurrence of lakarpite situated close to the Norra Kärr farm. Only a schistose variety of lakarpite is found here. It has a somewhat larger grain size than the schistose variety of the first occurrence, but otherwise shows no remarkable features distinguishing it from the varieties already mentioned.

b. Mineral Description.

The Feldspar Group. Albite is the dominating felsic mineral in lakarpite. It has megascopically a violet colour due to the pigmentation of fluorite. Microscopical examination shows that all individuals have very fine polysynthetical twin lamellae. Twinning has only been observed according to the albite law. The individuals have generally very ragged boundaries, but nevertheless a marked tendency to crystallographic development parallel to the albite twins is perceptible.

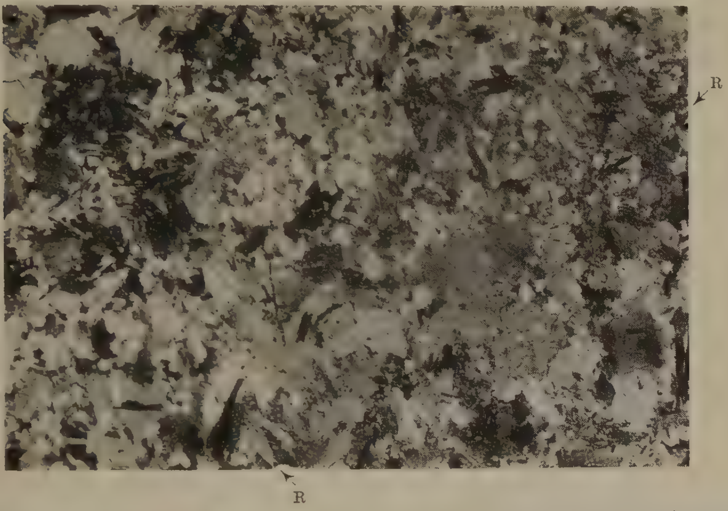

Fig. 20. Accumulations of microcline with an abundance of rosenbuschite. Aggregates of rosenbuschite are seen at the bottom, in the upper part of the right-hand side (indicated by arrows) and in the upper left-hand quarter of the picture. × nicols. Magnification: 10.

The optical properties are those of a very sodic plagioclase, the extinction angle in the symmetrical zone being 14°, corresponding to the composition $Ab_{92}An_8$. The indices of refraction are:

α: 1.529
β: 1.533
γ: 1.540.

The axial angle is $2V\gamma = 75°$.

Most of the albite individuals have uniform extinction, but some show a certain zonal growth, the margin being slightly more acid than the core. The albite is generally pigmented with fluorite occurring in grains arranged along the albite twins.

Feldspar with characteristic quadrille texture occurs in a subordinate amount in all kinds of lakarpite. As mentioned above it has sometimes accumulated to form a veritable microcline rock in certain parts of the lakarpite areas. The microcline individuals generally have diameters of one to two mm. They show anhedral forms but are well bounded showing no ragged outlines as is common for albite. The microcline always shows typical strain shadows, most pronounced in the schistose lakarpite varieties but also occurring in the massive ones. For this reason it is impossible to measure the extinction angle with any accuracy. The axial angle is small: $2V\alpha = 60°$, and thus points to a certain content of sodium. The indices of refraction are:

α: 1.529
β: 1.525
γ: 1.528.

With respect to the main lakarpite occurrence, no signs of perthitic intergrowth can be detected even with the highest magnification, either in the microcline or in the albite. The same is the case for most feldspar individuals in the lakarpite near the Norra Kärr farm. Here, however, individuals with a coarse perthitic or antiperthitic texture may occasionally be observed. The host crystals of the perthite are the same crosshatched microcline which generally occurs as nonperthitic individuals. This perthite does not resemble any of the textural perthite types described by Andersen (1929) from Norwegian granite pegmatites. The albite component has very irregular outlines forming smaller or greater patches, irregularly distributed and sometimes occupying the main part of the perthite. It is untwinned. Similiar perthites have been described by Eskola (1920, p. 51) in sviatonossite from Sviatoy Noss in Transbaikalia and by Ussing (1911, p. 135) in sodalite-foyaite from Ilimausak in Greenland. Eskola came to the conclusion that these perthites are of primary origin, the feldspar components having already separated at their crystallization. Probably this holds true also for the perthites in the lakarpite.

As for the antiperthite, the texture resembles that of the perthite except that the patches of potash feldspar are more regularly distributed, being arranged along the albite twins of the host crystal. The host crystal of the antiperthite is the same polysynthetically twinned albite which generally occurs as nonperthitic individuals. The potash feldspar of the patches is untwinned. The antiperthite is also assumed to be of primary origin, since the other conceivable modes of origin, exsolution or replacement, are highly improbable.

Nepheline. Nepheline occurs in anhedral but well-bounded individuals of one to three mm size. In the massive lakarpite the nepheline individuals show a tendency to gather in certain parts of the rock, very much in the same way as the arfvedsonite crystals, but as they are hardly distinguishable megascopically from the feldspars, this phenomenon can only be observed under the microscope. The nepheline individuals are perfectly fresh in all lakarpite varities, but along cracks some dark material has sometimes been deposited. The indices of refraction of the nepheline are:

$$\varepsilon\colon 1.534$$
$$\omega\colon 1.538.$$

Arfvedsonite. Amphibole crystals of different lakarpite varieties have all the same indices of refraction and the same extinction angle, but show some variation in pleochroism. The amphibole is generally euhedral in the prismatic zone and usually shows anhedral terminations, pyramidal faces being only occasionally developed. Most individuals have no inclusions, but some are poikilitically intergrown with albite. The amphibole grains have maximum diameters of two to four mm. Optical observations are rendered difficult because of the strong pleochroism and the dark colours. All observations in convergent light are especially uncertain. The optical properties are as follows:

$$X \wedge c = 20^\circ - 25^\circ$$
$$2V\alpha = 69^\circ.$$

As has been stated the pleochroism varies somewhat in intensity. The strongest colours are:

X: dark bluish green, Y: dark bluish green, Z: brownish green

$$X = Y > Z.$$

Dispersion is strong, $r > v$.

Törnebohm reported the optical orientation of this amphibole to be Y = b. However, as far as can be judged from the very indistinct interference figures, it seems that the axial plane lies at right angles to the plane of symmetry and the optical orientation should therefore be Z = b. This observation is also in accordance with the result obtained by Sahama, mentioned in an investigation of the extinction angles of certain amphiboles which he carried out together with Eskola (1930 b, p. 14).

The indices of refraction are:

$$\alpha\ 1.652 \pm 0.005$$
$$\beta\ 1.660 \pm 0.005$$
$$\gamma\ 1.666 \pm 0.005.$$

The optical properties indicate that the amphibole is of arfvedsonitic character. The extinction angle is, however, greater than that for most amphiboles described as arfvedsonite. An alkali amphibole from Kiihtelysvaara in Finland has an identical extincion angle, according to the observations of Eskola and Sahama (1930 a, p. 8). This amphibole also resembles the arfvedsonite from Norra Kärr in having a similiar optical orientation, but the indices of refraction are much greater.

Rosenbuschite. When Törnebohm recognized rosenbuschite in Norra Kärr in 1906 it was only known from the type locality at Langesundsfjord (Brögger 1890, p. 378). Since that time it has been reported from a few more localities, e.g. in tinguaite from the Los Archipelago according to Lacroix (1911, p. 73), from Red Hill, Moultonboro, N. Hampshire according to Pirsson (1907, p. 434) and from Mt. Khibines according to Fersman (Polkanov, 1937, p. 96). It is thus an extremely rare mineral and each occurrence deserves attention. The finding of rosenbuschite at Norra Kärr has not been noticed by the authors of mineralogical textbooks, the locality being mentioned neither in Rosenbusch's Mikroskopische Physiographie (1925) nor in Dana's Textbook of Mineralogy (1932). I will therefore draw attention to the occurrence of this mineral at Norra Kärr, especially as Törnebohm's description gives information about the twinning structure of this mineral, which has not been recorded from the other localities.

No complete chemical analysis of the mineral from Norra Kärr has been made, but qualitative tests carried out by Mauzelius showed the presence of zirconium and titanium, and the optical properties are in close agreement with those of rosenbuschite. The diagnosis can therefore be regarded as certain.

In the lakarpite, rosenbuschite occurs as a subordinate constituent, but far too abundantly to be counted as an accessory. The mineral has the form of long rods or needles, sometimes occurring isolated but most often in radiating aggregates. The rods may be up to two mm in length and $^1/_2$ mm in width. The aggregates may have a size of up to five mm. Rosenbuschite has a perfectly euhedral development, penetrating all other minerals of the lakarpite. The colour is a dirty pale yellow with almost imperceptible pleochroism. Before presenting the optical properties, a few words may be said about the symmetry of rosenbuschite. Brögger (1890) regarded it to be monoclinic. Peacock (1937 a), who also worked with material from Langesundsfjord, found rosenbuschite to be triclinic with a pseudomonoclinic symmetry. Brögger's original setting of the rosenbuschite was abandoned and a new setting adopted (1937 a, p. 20 and 1937 b, p. 588).

The optical properties of rosenbuschite from Norra Kärr correspond quite well with those of rosenbuschite from Langesundsfjord. The direction of vibration of the fastest ray is coincident with the long axis of the rods. Thus the optical orientation is X = b in Brögger's setting of rosenbuschite and X = c in the setting applied by Peacock. A distinct cleavage is seen after (100) (Peacock's setting). The dispersion of the optic axes is weak, $r > v$. The indices of refraction and the axial angle can be seen from the following table where they are compared with corresponding values of the rosenbuschite from Langesundsfjord as determined by Peacock (1937 a, p. 29).

	Norra Kärr	Langesundsfjord
α	1.680	1.678
β	1.687	1.687
γ	1.708	1.705
$2V\gamma$	68°	78°

For a more complete mineralogical description reference may be made to Törnebohm's original paper (1906, p. 20).

Apatite. Apatite occurs as an accessory in partly well-shaped crystals of up to one mm size. It sometimes has inclusions of fluorite. It is optically fully normal and needs no further description.

Titanite. Titanite occurs less abundantly than apatite. Generally not more than one or two grains are seen in each thin section. They are, however, larger than the apatite grains, about two mm. The colour is pale brown.

Fluorite. As mentioned under the description of albite and apatite, fluorite occurs as pigmentation in these minerals. In a schistose akarpite variety it is also found in independent individuals, very rregularly distributed.

Låvenite. In the schistose lakarpite variety occurring near the Norra Kärr farm, a mineral which is believed to be identical with åvenite was observed as a rare accessory occurring in narrow rods of one mm length. It is almost completely altered into a dark brownish material with lower index of refraction than the original material. Under the microscope it can be seen that the colour of the unaltered mineral is pale yellowish. This mineral is probably låvenite, of which he appearance and the observable optical properties correspond with hose of a låvenite variety from Langesundsfjord as described by Brögger (1890, p. 341).

Brögger identified two låvenite varieties at Langesundsfjord: »Der Farbe nach können zwei verschiedene Varietäten des Låvenit unterschieden werden; die eine Varietät ist hellgelb, bisweilen fast farblos, oder hessonitgelb; die andere ist dunkel rothbraun bis schwarzbraun gefärbt.» The dark låvenite is always fresh but the yellow variety is generally altered as appears from the following statements: »Der hellgelb gefärbte Låvenit scheint zum Theil nicht mehr ein ganz ursprüngliches, unverändertes Mineral zu sein.» »Im Dünnschliffe sieht man, dass von dem ursprünglichen Låvenit oft kein Spur mehr vorhanden, sondern dass derselbe vollständig pseudomorphosiert ist.»

Both the fresh material and the alteration product of the mineral from Norra Kärr bear a striking resemblance to the corresponding components of the yellow låvenite variety from Langesundsfjord. It is, however, so extensively pseudomorphosed that optical observations on the fresh material are rendered difficult. The indices of refraction of låvenite from Langesundsfjord as determined by Larsen and Berman (1934) are: α: 1.698, β: 1.723, γ: 1.745 and $\gamma - \alpha$ 0.047. The medium index of refraction of the mineral from Norra Kärr is determined as 1.720 and the double refraction can be estimated to be 0.04, thus showing satisfactory agreement with låvenite.

Unidentified mineral. A mineral which it has not been possible to identify is sometimes found as an accessory in peripheral parts of the main lakarpite area. It occurs as small rods of prismatic habit showing very indistinct cleavage parallel to the prism. Pleochroism is very weak, almost imperceptible, in light yellowish brown colours. The mineral is biaxial positive and all individuals observed show parallel extinction. The axial plane is transverse to the cleavage. The dispersion is weak $r < v$. The indices of refraction are:

α: 1.650
β: 1.655
γ: 1.663.

The axial angle is $2V\gamma$: 65°.

These data do not correspond with the optical properties of any mineral species given in the current mineralogical tables. The material is however too scanty to allow a closer examination. The mineral which comes closest to it in optical properties is hiortdahlite, which has the following indices of refraction: α: 1.652, β: 1.658, γ: 1.665. It is however triclinic and shows an extinction angle of 65° on (100). For petrographical reasons it is considered probable that the mineral in question also is a zirconium silicate.

c. Petrographical Character.

A microscopical study of the different lakarpite varieties reveals that the differences between them are more dependent on structural properties than on mineralogical, even if there may be some variation in the relative proportions of the minerals of different varieties, especially with respect to the essential minerals albite, arfvedsonite and nepheline. Sometimes the lakarpite passes by gradual transition into more mafic types than the average rock and sometimes into more salic types. In the former case the transition takes place by means of increase in the amount of arfvedsonite, in the latter by means of decrease in the amount of the same mineral.

At the main lakarpite occurrence the feldspars are never perthitic. The albite individuals have about the same size as arfvedsonite and nepheline (three mm), whereas the microcline grains are much smaller. The albite individuals have ragged boundaries and are often intergrown with small albite grains and sometimes with nepheline grains. They are polysynthetically twinned after the albite law, and are generally pigmented with fluorite, occurring in grains arranged along the albite twins. Albite is always perfectly fresh and the same is the case with the nepheline and the microcline. No variation can be observed in the extinction angles of albite belonging to different lakarpite varieties. In the schistose lakarpite variety near the Norra Kärr farm, perthitic and antiperthitic feldspars are occasionally seen together with nonperthitic. The host crystals then consist of the ordinary microcline and albite respectively.

The other minerals show no perceptible changes in habitus or optical properties from the one lakarpite variety to the other. Arfvedsonite occurs as broad prisms usually with well developed prism faces. It is ometimes poikilitically intergrown with albite. Rosenbuschite appears s isolated rods or in radiating aggregates showing strong idiomorphism. Nepheline, on the other hand, shows anhedral boundaries with all the ther minerals. Apatite and titanite only occur in accessory amounts, patite in well shaped crystals whereas titanite shows less pronounced diomorphism.

The unidentified mineral is found at the main lakarpite occurrence, ear to the contact with grennaite where lakarpite shows evidence of ntermixture with grennaite material. It never occurs together with osenbuschite. It is mostly found in isolated rods from one mm up to our mm long, but sometimes in asteroid aggregates very much like those f rosenbuschite. Its mode of occurrence resembles on the whole that of osenbuschite and it can be said to act as substitute for this mineral in

Table 18.

Analysis of lakarpite, Norra Kärr.

Analyst: Naima Sahlbom, 1942.

	Weight %	10 000 M	Norm	Mode Vol.%		Niggli's system	
SiO_2	52.04	8 630	Or ... 22.77	Albite		qz	: 92
TiO_2	0.90	112	Ab ... 27.46	$Ab_{92}An_8$	36	si	142
ZrO_2	0.24	20	Nef ... 17.34	Microcline	7	ti	1.48
Al_2O_3	15.73	1 539	Z 0.37	Nepheline	21	zr	0.33
Fe_2O_3	2.84	178	Σsal .. 67.94	Arfvedsonite	31	p	0.97
FeO	4.27	594	wo 6.10	Rosenbuschite	3		
MnO	0.26	37	en 3.53	Apatite	1	al	25.2
MgO	2.79	692	fs 2.28	Fluorite	1	fm	27.5
CaO	4.66	831	fo 2.40		100	c	13.7
BaO	trace		fa 1.71			alk	33.6
Na_2O	10.17	1 640	Na_2SiO_3 6.23				
K_2O	3.84	408	il 1.70			mg	0.41
P_2O_5	0.84	59	mt.... 4.12			k	0.20
$H_2O > 105°$ ...	0.62		ap 2.07				
$H_2O < 105°$ ...	0.14		fl 1.06			c/fm	0.50
F	0.51	268					
Cl	0.06	17	Σ fem .31.20				
	99.91		H_2O .. 0.76				
Less O for F, Cl	0.23		99.90				
	99.68						

Quantitative System: II : 6 : 1 : 4, Lardalose.

the rock types where it occurs, which makes it probable that it also is a zirconium silikate.

The låvenite mineral is found at the lakarpite occurrence near the Norra Kärr farm. It occurs in narrow rods or needles up to one mm in length. Like the above mentioned mineral it is only found in the peripheral parts of the lakarpite area.

d. Chemical Composition.

For chemical analysis the massive lakarpite variety constituting the two well-rounded bodies in the main lakarpite area was chosen. The characteristic chemical qualities of this rock as compared with other nepheline-syenites are seen to be: great preponderance of soda over potash, ferrous iron dominating over ferric iron, and a low content of aluminium. The great excess of alkalis over aluminium places the rock in Ussing's agpaite subgroup of the nepheline-syenite family. According to Ussing (1911, p. 341) the agpaites may be characterized by the equation.

$$\frac{na + k}{al} \geqq 1.2,$$

Table 19.

	1	2	3	4
SiO_2	52.04	55.12	51.81	54.54
TiO_2	0.90	0.36	0.35	1.24
ZrO_2	0.24	0.84	2.05	—
Al_2O_3	15.73	16.28	13.68	19.90
Fe_2O_3	2.84	8.66	7.32	2.59
FeO	4.27	3.53	7.27	2.81
MnO	0.26	0.29	0.57	0.15
MgO	2.79	0.03	0.09	1.59
CaO	4.66	0.77	3.06	2.79
BaO	trace			0.03
Na_2O	10.17	11.30	9.75	8.39
K_2O	3.84	2.75	3.92	4.98
P_2O_5	0.84	trace	—	0.64
$H_2O > 105°$	0.62			0.63
$H_2O < 105°$	0.14			0.02
F	0.51			—
Cl	0.06	0.09	0.16	0.11
FeS_2				0.02
	99.91	100.02	100.03	100.43

1. Lakarpite, Norra Kärr.
2. Lujavrite, Ilimausak (Ussing 1911, p. 344). Approximate mean composition from four analyses.
3. Kakortokite, Ilimausak (Ussing 1911, p. 344). Approximate mean composition of nine parts of white kakortokite, one part of red, and three parts of black kakortokite.
4. Lardalite, Oslo district (Brögger, 1933, p. 74). Mean composition from four analyses »von normalen Tiefengesteinen der Lardalit-Reihe».

na, k and al representing »the relative amounts of Na-, K- and Al-atoms in the rock». »In the agpaites of Ilimausak the ratio varies from 1.2 to 2.1, while in ordinary nepheline-syenites the ratio is from 0.8 to 1.1.» The lakarpite has the ratio 1.3.

The agpaites of Greenland comprises sodalite-foyaite, naujaite, lujavrite and kakortokite. The lakarpite cannot, however, be classified under any of these terms, being distinctly different in mineralogical as well as in chemical composition, particularly with respect to the iron content.

The existence of arfvedsonite in the rock instead of aegirite, the common dark mineral in nepheline-syenites, is expressed in the analysis by the fact that ferrous iron is distinctly dominant over ferric iron. The plagioclase is very sodic; the calcium of the analysis must therefore have entered the mafic minerals, essentially arfvedsonite. In this respect lakarpite resembles the canadite subgroup of the nepheline-syenite family as defined by Quensel (1914, p. 177).

The norm is characterized by the absence of anorthite, all aluminium being used in the formation of alkali feldspars and nepheline. The calcium of the analysis therefore appears as normative wollastonite. The extremely alkaline character of the rock is manifested in the norm by an extraordinarily great content of sodium metasilicate.

In the quantitative system, the rock has the position II : 6 : 1 : 4, Lardalose. Lakarpite shows a higher alkali content than does lardalite and a corresponding smaller content of aluminium. Otherwise there is a closer correspondence between the chemical composition of lakarpite and lardalite than between lakarpite and the agpaitic rocks of Greenland, as can be seen from Table 19.

2. Pulaskite.

a. Field Observations.

Near the western border of the Norra Kärr district, in its northern half, a rock which may be referred to as pulaskite was found at

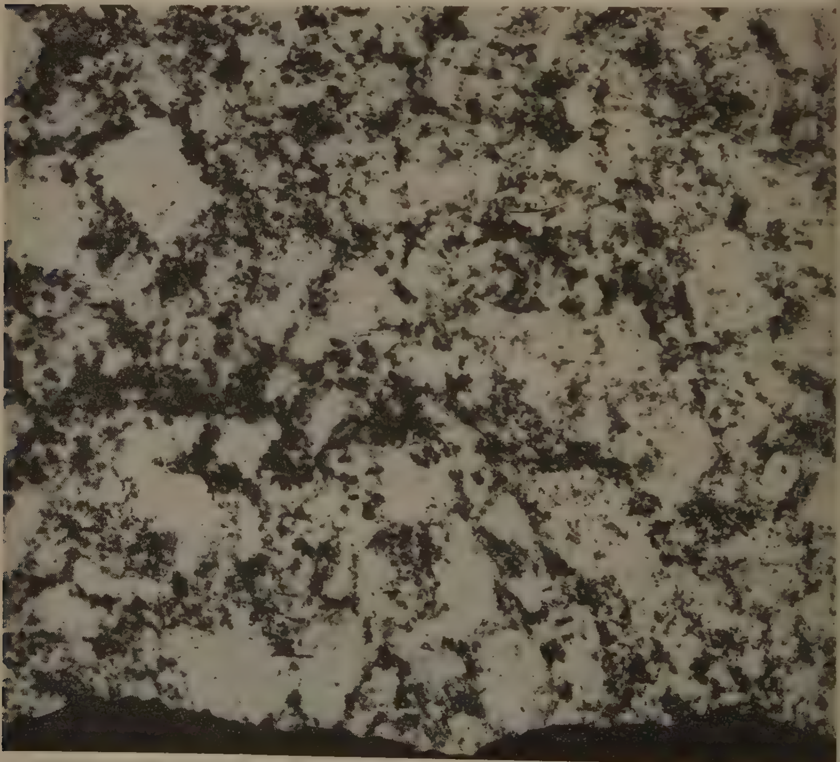

Fig. 21. Pulaskite. Amphibole, aegirite and biotite appear dark. Light areas are essentially microcline and albite. (Photo S. Hedlund.) Magnification: 1¹/₄.

some places. It was discovered quite by chance, when the moss was scratched away from the side of a small slope. A closer inspection showed that the rock had a comparatively great extension. It is, however, no wonder that the pulaskite escaped the attention of the first investigators of the Norra Kärr district, the rock being completely covered by moss and soil. On the map it can be seen that the pulaskite occurs in five small areas, the largest of which is fifty metres long and twenty metres wide. The extension of the pulaskite areas could not be stated with any high degree of accuracy, as there was often a comparatively great distance between places where it was possible to disclose the rock surface. The pulaskite outcrops, not separated by grennaite outcrops, were grouped together into a common pulaskite area, but it is of course possible that some of these areas in fact consist of several smaller areas separated by grennaite. Only with respect to the main occurrence can it be said with certainty that it is a continuous pulaskite area, as it has been possible to uncover it from the one end to the other.

The pulaskite is on the whole rather uniform, showing by no means such a diversity of types as lakarpite. It is massive, with an indistinct porphyritic appearance brought about by irregularly bounded feldspar phenocrysts. The contact with grennaite is nowhere exposed, which renders impossible the study of any contact facies.

b. Mineral Description.

The Feldspar group. Microcline is by far the most important mineral of the pulaskite. Under the microscope all grains are seen to show the characteristic grating texture. The extinction angles cannot, however, be measured, owing to the strong strain shadows invariably present. The axial angle is small, about 60°, indicating a certain sodium content. This can also be deduced by comparing the actual mineral composition of the rock with the norm, the microcline constituting 42 per cent of the rock, whereas the norm contains only 23.72 per cent Or. In most individuals no signs of perthitic texture can be detected, not even with the highest magnification. Some individuals contain, however, a few albite lamellae in perthitic intergrowth in a part of the crystal, usually in a corner.

The indices of refraction of the microcline are

α: 1.520
β: 1.525
γ: 1.528.

The albite is polysynthetically twinned after the albite law. It is sometimes pigmented with fluorite as was the albite of the lakarpite.

The medium index of refraction lies below that of the embedding material, kollolite, which has index of refraction 1.534. The maximum extinction angle in the symmetrical zone was found to be 15°, corresponding to $Ab_{93}An_7$.

Nepheline. Nepheline is only an accidental constituent of pulaskite. Some thin sections may be quite devoid of this mineral, whereas in others it may be present to an amount of five to ten per cent. The nepheline is not quite fresh. Parts of it are generally altered into a light brown material with higher index of refraction than the fresh mineral, identical with the gieseckite pseudomorphs previously described.

Aegirite. Aegirite occurs in about three mm long individuals, euhedral in the prismatic zone. This aegirite is distinct from that of the grennaite, differing both in pleochroism and in extinction angle. The pleochroism is

X: brownish green, Y: light brownish green, Z: yellowish green.

$$X > Y > Z$$

whereas the aegirite of the grennaite has darker colours. The extinction angle is

$$X \wedge c = 10°$$

whereas for the aegirite of the grennaite it was 2°—4°. The axial angle is $2V\alpha = 61°$.

The borders of the individuals have sometimes a somewhat smaller extinction angle than the cores, indicating a purer aegirite.

Amphibole. The amphibole occurs as broad laths of two or three mm length, sometimes poikilitically intergrown with untwinned feldspar and apatite. Optical determinations are rendered difficult by the dark colours and the strong pleochroism as was the case for the arfvedsonite of the lakarpite. The axial plane is found to lie parallel to the plane of symmetry and the optical orientation is therefore $Y = b$. The axial dispersion is strong, $r > v$. The axial angle is large with an optically negative sign, $2V\alpha = 80°$. The extinction is very indistinct and cannot be measured with any great accuracy. It is approximately $X \wedge c = 40°$. The indices of refraction are

$$\alpha: 1.648 \pm 0.005$$
$$\beta: 1.656 \pm 0.005$$
$$\gamma: 1.662 \pm 0.005.$$

The pleochroism is:

X: deep bluish green, Y: bluish green, Z: dirty green, with a yellowish tint.

$$X > Y > Z$$

In optical properties this amphibole may be said to occupy an intermediate position between the arfvedsonite of the lakarpite and the eckermannite of the kaxtorpite.

Biotite. Biotite generally occurs as small flakes of about two mm diameter, with strong pleochroism:

X: pale yellow, almost colourless, Y: reddish brown,
Z: deep reddish brown

$$X < Y < Z$$

It should be mentioned that the axial angle is quite perceptible, 5° to 10°. Otherwise the optical characters are those characteristic for biotite.

Rosenbuschite. This mineral occurs in much the same way as in lakarpite, forming perfectly euhedral crystals penetrating the feldspar individuals. It is, however, not so abundant as in lakarpite.

Titanite. An ordinary optically positive titanite of grayish colour occurs as an accessory. It is most often found together with the other dark minerals, in grains of up to one mm size.

Fluorite. As mentioned, fluorite is sometimes found as pigmentation in albite. Occasionally independent grains may be observed as an interstitial mass between the other minerals.

Apatite. Apatite occurs in small euhedral crystals, sometimes as inclusions in amphibole.

Apart from this ordinary apatite, however, a radioactive mineral belonging to the apatite group is also found. This mineral has a mode of occurrence similar to that, for example, of orthite in certain granites, the rock around the mineral showing a typical radiate structure. The mineral shows megascopically a brownish colour and has the form of oval individuals up to one cm in diameter. The peripheral parts sometimes show yellowish decomposition products. The mineral preferably occurs in the biotite-rich parts of pulaskite. It is, however, never found as inclusions in biotite.

Under the microscope the greater part of the mineral proved to be isotropic. The index of refraction was found to be 1.77. An X-ray powder diagram of the original mineral gave no result.[1] On ignition, however, the mineral recrystallized and a diagram of the recrystallized material proved it to belong to the apatite type. Qualitative X-ray spectrographic analysis showed the presence of yttrium and thorium. A radioactive yttrium-containing mineral of the apatite group has been described from Iisaka, Fukushima prefecture, by Shin Hata (1938, p. 1018) under the name of abukumalite. The mineral from Norra Kärr is probably closely related to abukumalite. Machatschki (1939 a, p. 161), and Hägele and Machatschki (1939 b, p. 165) refer to this mineral as yttrium-lanthanide silica apatite in distinction to britholite which is a cerium-lanthanide silica apatite.

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[1] The physical examination of the mineral was carried out by Mr. O. Alvfeldt of the Geochemical Laboratory of the Boliden Mining Company.

It was under the present circumstances not possible to obtain material of the original abukumalite for comparison. The Mineralogical Institute was, however, in possession of some specimens of britholite from the type locality Naujakasik in Greenland (Winther, 1899, p. 190). X-ray powder diagrams of the britholite and the Norra Kärr mineral showed nearly identical patterns.

c. Petrographical Character.

The essential constituent of the rock is the highly sodic microcline, forming up to one centimetre large individuals which are extremely ragged and are surrounded by granulated zones of feldspar. The albite individuals are generally smaller than the microcline, but they are also surrounded by granulated zones of feldspar. Nepheline is only found occasionally and then interstitially between microcline and albite. Strain shadows are abundant, particularly in the microcline, but also in the albite.

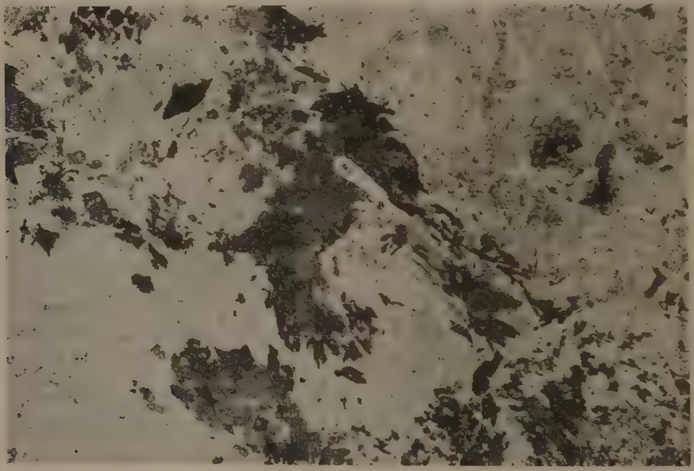


Fig. 22. Pulaskite. Dark areas are essentially amphibole but also include some aegirite. In the right half of the picture and in the upper left corner are seen a few flakes of biotite. In the upper left corner may also be observed a titanite crystal. The lower left corner consists of microcline; the upper right corner consists of albite pigmented by fluorite.

Aegirite is the most abundant of the dark minerals, followed by biotite and then amphibole. Rosenbuschite, apatite, titanite and fluorite only occur as accessories. The dark minerals have a marked tendency to cluster together, aegirite, biotite and amphibole being found only seldom as isolated individuals. There is an enrichment of biotite in some parts of the rock at the expence of aegirite. In these parts biotite may form flakes of two or three centimetres diameter, but generally the biotite individuals are only one or two mm long. Aegirite and amphibole are somewhat larger. These minerals are euhedrally bounded by biotite but show varying mutual relations with respect to idiomorphism. Rosenbuschite, titanite and apatite are euhedrally bounded by all other minerals. Apatite is found especially often as an inclusion in the amphibole.

d. Chemical Composition.

This rock has not such a decided alkaline character as those hitherto described. This appears from the fact that it is not necessary to introduce acmite in the norm, the amount of aluminium being sufficient to form feldspars with all the sodium and even with some of the calcium. The aegirite present in the mode is thus not represented in the norm. On the other hand we have anorthite in the norm whereas the modal plagioclase is highly sodic — $Ab_{93}An_7$. The essential part of the calcium must therefore enter the dark minerals. In this respect the rock resembles the canadite of Quensel (1914, p. 177) as did the lakarpite.

Chemically the rock occupies an intermediate position between nepheline-syenite and syenite. The position in the quantitative system is II : 5 : 1 : 4, Umptekose. However, both the class and the rang approach a neighbouring group. The ratio between alkalis and salic lime, determining the rang, brings the rock near II : 5 : 2 : 4, Akerose. A somewhat smaller amount of the femic constituents would have placed the rock in Class I, in the subrang Nordmarkose approaching Larvikose.

In chemical composition the rock is closely related to pulaskite, larvikite and umptekite, as can be seen from Table 21. Johannsen (1938, p. 5) has grouped these rocks together in the pulaskite family, deeming that the term pulaskite may be used in a broader sense than larvikite and umptekite. Rosenbusch (1923, p. 149), on the other hand, saw pulaskite in connection with nordmarkite, regarding it as a somewhat less silicaceous equivalent. The definition of Johannsen does not, however, differ essentially from that of Rosenbusch. The Norra Kärr rock meets all the requirements of the term pulaskite according to both definitions.

Table 20.

Analysis of pulaskite, Norra Kärr.

Analyst: Naima Sahlbom, 1943.

	Weight %	10000 M	Norm		Mode Vol%		Niggli's system	
SiO_2	58.89	9766	Or....	23.72	Albite		qz	: 34
TiO_2	0.24	30	Ab....	48.38	$Ab_{93}An_7$	34	si	186
ZrO_2	0.15	12	An....	5.66	Microcline	42	ti	0.58
Al_2O_3	17.34	1697	Nef...	4.34	Nepheline	4	zr	0.23
Fe_2O_3	2.77	174	Hl....	0.20	Aegirite	9	p	0.44
FeO	2.13	296	Z	0.22	Amphibole	5		
MnO	0.16	23	Σsal ..	82.52	Biotite	4	al	33.5
MgO	1.56	387			Apatite	0.5	fm	21
CaO	4.22	752	wo....	5.92	Titanite	0.5	c	15.5
BaO	0.48	31	en	3.89	Rosenbuschite		alk	30
Na_2O	6.72	1084	fs.....	1.27		0.5		
K_2O	4.00	425	il.....	0.46	Fluorite	0.5	mg	0.37
P_2O_5	0.32	23	mt....	4.02		100	k	0.28
$H_2O > 105°$ ...	0.52		ap....	0.83				
$H_2O < 105°$ ...	0.15		l.....	0.20			c/fm	0.70
Pb	0.14	7	pr	0.27				
F	0.08	42	PbS...	0.19				
Cl	0.19	54	Σfem..	17.05				
S	0.17	53						
	100.23		H_2O...	0.67				
				100.24				
Less O for Pb, F, Cl, S	0.14							
	100.09							

Quantitative System: II : 5 : 1 : 4, Umptekose.

3. The Kaxtorpite Group

(pectolite-eckermannite-aegirite-nepheline-syenite, eckermannite-aegirite-nepheline-syenite and eckermannite-aegirite-syenite).

The term kaxtorpite covers three rocks characterized by some minerals not found in the other rocks of the Norra Kärr district. These minerals are: a peculiar alkali amphibole described as eckermannite, aegirite of a certain habit and pectolite. Further essential minerals are microcline, albite and nepheline. The kaxtorpite rocks contain no zirconium minerals, a conspicuous feature distinguishing them from the other rocks of the district.

Among themselves the kaxtorpite rocks show a considerable variation in the relative proportions of the main constituents, especially nepheline, feldspars and pectolite, which distinguish them from each other. It has, however, been considered unnecessary to emphasize this difference by giving them separate names, though they belong chemically to so widely separated types as Lardalose and Nordmarkose, as

Table 21.

	1	2	3	4
SiO_2	58.89	57.80	60.20	63.71
TiO_2	0.24	1.15	0.14	0.86
ZrO_2	0.15	—	trace	
Al_2O_3	17.34	18.82	20.40	16.69
Fe_2O_3	2.77	1.60	1.74	2.92
FeO	2.13	3.50	1.88	0.66
MnO	0.16	0.14	trace	0.20
MgO	1.56	1.48	1.04	0.90
CaO	4.22	3.72	2.00	3.11
BaO	0.48	0.17	trace	
SrO		0.13		
Na_2O	6.72	6.48	6.30	8.26
K_2O	4.00	3.97	6.07	2.79
P_2O_5	0.32	0.55	0.15	—
CO_2		0.10	none	
SO_3			0.13	
$H_2O > 105°$	0.52	0.64	0.23	0.19
$H_2O < 105°$	0.15	0.02	0.10	
Pb	0.14			
F	0.08	0.04		
Cl	0.19	0.05	0.09	
S	0.17	0.03	none	
	100.23	100.39	100.47	100.29

1. Pulaskite. Norra Kärr. Analyst: Naima Sahlbom, 1943.
2. Larvikite. Langesundsfjord (Brögger, 1933, p. 59. Analyst: O. Röhr, 1917).
3. Pulaskite. Fourche Mountain, Pulaski Co., Arkansas (Washington 1901, p. 609. Analyst: Washington 1901).
4. Umptekite. Umpjaur, Kola Peninsula (Ramsay and Hackman 1894, p. 206. Analyst: W. Pettersson 1894).

expressed in terms of the quantitative system. Mineralogically they form a well defined group, distinct from the other phanerocrystalline rocks.

According to their contents of pectolite, the kaxtorpite rocks may be divided as follows:

1. Pectolite-rich kaxtorpite (pectolite-eckermannite-aegirite-nepheline-syenite).
2. Pectolite-poor kaxtorpite.
   a. with nepheline (eckermannite-aegirite-nepheline-syenite).
   b. without nepheline (eckermannite-aegirite-syenite).

a. Field Observations.

The three members of the kaxtorpite group occur in three different areas separated from each other by grennaite, as are the other areas of phanerocrystalline rocks. The rocks within a certain area show only slight variations in composition. Thus there occur no rocks occupying a transitional position between the types mentioned. The habit of each rock generally enables it to be distinguished from the others merely by inspection of a hand specimen.

The pectolite-rich kaxtorpite covers the largest area. It is situated southwest of the farm Norra Kärr, on the western side of the road to Kaxtorp, and forms a lens-shaped area about 150 m long and 75 m wide. Within this area solid rock crops out at half a dozen places. The rock is easily affected by weathering agencies, acquiring a gritty surface often several centimetres in depth. Generally the rock contains centimetre-large crystals of glassy microcline subparallelly arranged, giving it a marked schistose appearance, accentuated by aegirite needles and amphibole laths oriented in the same direction. The schistosity is not very consistent, but in general it forms only small to moderate angles with the long axis of the area.

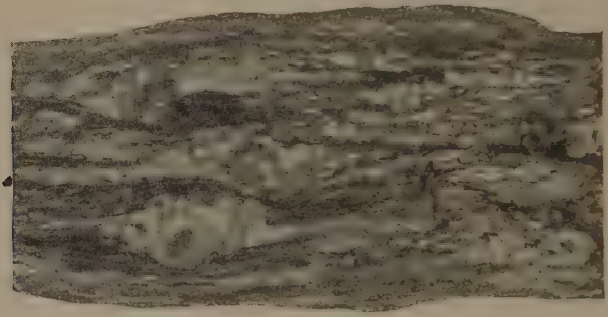


Fig. 23. Kaxtorpite, type 1. Polished surface, perpendicular to the schistosity. Natural size. Observe the large microcline crystals. (Reproduced from Törnebohm, 1906, p. 25.)

The contact with grennaite is exposed at only one place situated on the western side of the area, in its central part. The two rocks have here parallel schistosity. The schistosity of grennaite evidently follows the outlines of the kaxtorpite area. It thus seems probable that the kaxtorpite area represents a section through a body enclosed in grennaite and that the grennaite solidified after the formation of this body.

The area of pectolite-poor but nepheline-bearing kaxtorpite is situated on the border between the provinces of Småland and Östergötland, some 100 m east of the road between Norra Kärr and Lakarp. The area has an extension of about 70 m in a north—south direction and has a maximum width of 20 m. The northern part of it is ovally bounded by grennaite, while the southern part has the form of a narrow tongue bent somewhat to the southeast.

The rocks are on the whole schistose and in a direction parallel to the long axis of the area. Sometimes, however, parts of massive kaxtorpite occur enclosed in the schistose variety, particularly near the eastern contact. The massive parts are clearly bounded and have proved to have the same composition as the schistose rock. The contact with the grennaite may be studied on the eastern side of the area, where the border is exposed on the slope of a small hill, the lower part of which consists of grennaite. A sketch (Fig. 24) shows the character of the contact. The schistosity of both rocks run parallel and the grennaite

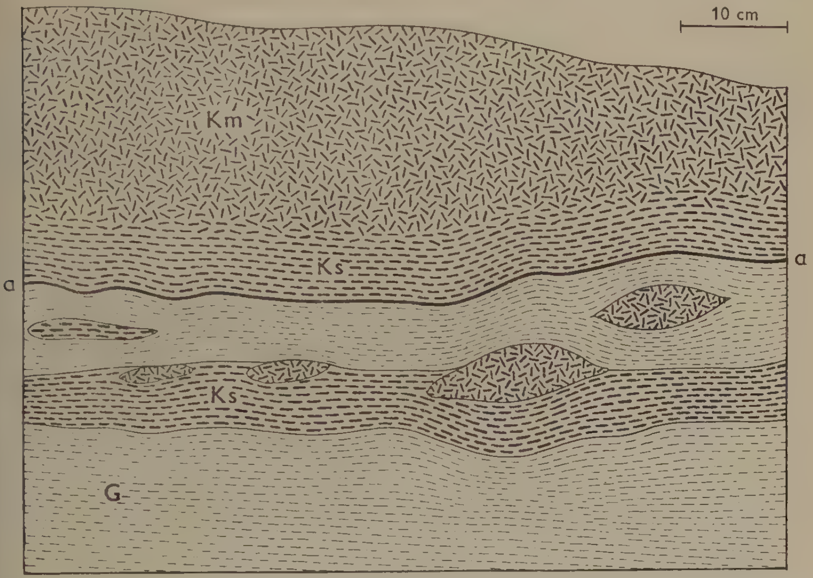


Fig. 24. The border (a—a) between the body of kaxtorpite, type 2 a and grennaite. Below the border is seen a streak of schistose kaxtorpite. Small boulders of massive axtorpite are enclosed in the grennaite and also in the streak of schistose kaxtorpite. G: grennaite, Km: massive kaxtorpite, Ks: schistose kaxtorpite.

lips under the kaxtorpite at an angle of about 70°. Grennaite has the ame appearance up to the very contact showing no signs of marginal acies, whereas the kaxtorpite area shows hybrid rocks nearest to the ontact, containing typical grennaite minerals such as eudialyte and atapleite. It is, however, only the schistose kaxtorpite variety which hows a hybrid character, the small parts of massive kaxtorpite being naltered even when they occur as inclusions in grennaite.

Törnebohm (1906, p. 23) claimed to have seen an inclusion of granite t this locality. I have not been able to verify this observation. Dark nclusions in the kaxtorpite are rather common. They have proved to e accumulations of aegirite and amphibole. They are generally not nore than ten centimetres long.

Pectolite-poor and nepheline-free kaxtorpite occur at one place in the southern part of the Norra Kärr district, somewhat southwest of the main kaxtorpite area. The only outcrop is found on the side of a small hill, about fifteen metres in diameter, which probably consists altogether of kaxtorpite. The contact with grennaite is seen at the foot of the hill whence the kaxtorpite extends upwards and disappears under the vegetation. The two rocks show a similar relation to each other as was described from the last mentioned kaxtorpite area, with the exception that no parts of massive kaxtorpite occur. Eudialyte grains up to five mm in diameter, evidently derived from the grennaite, are seen here and there in the kaxtorpite. Completely uninfluenced rock was not observed at this locality. The dark inclusions already mentioned seemed to be more abundant than at the other occurrence.

b. Mineral Description.

The Feldspar Group. The centimetre-large feldspar crystals which give the pectolite-rich kaxtorpite its porphyritic appearance consist of generally nonperthitic microcline. The individuals are elongated along the axis *b*, and have a subparallel arrangement. They have a tabular development, the predominant faces being (001) and (010). On (001) the lustre is glassy and the cleavage almost perfect. The cleavage at (010) is much poorer. At (100) also there is a tendency to imperfect cleavage. The larger crystals are generally better developed than the smaller ones. The crystals have crystallographical boundaries against the groundmass along their long axes which are parallel to the faces (001) and (010), but are irregularly terminated at the ends.

Under the microscope the characteristic grating texture of the microcline is seen in sections parallel to (001). The grating texture is usually fine and regular but may be coarse and then more irregular. The extinction angle may be measured with accuracy since strain shadows are generally absent. The extinction angle on (001) is 15°; on (010) it is 3°. The axial angle is small; the isogyres are always seen to turn within the observational field when studied in convergent light. An accurate measurement on the universal stage gave $2V\alpha = 60°$. The indices of refraction are:

α: 1.520
β: 1.525
γ: 1.529.

A partial quantitative spectrographical analysis of the microcline crystals, carried out at the Geochemical Laboratory of the Boliden

Mining Company, gave the following result with a possible error of ± 10 %.

Na_2O	2.48	Weight %
Rb_2O	0.30	»
Cs_2O	< 0.10	»

This corresponds to a feldspar of the composition $Kf_{78}Naf_{21}Rbf_1$. It is thus a soda microcline.

Perthitic texture is only seldom seen in the microcline crystals of the pectolite-rich kaxtorpite. It is, however, more common in the two pectolite-poor types, though it is not abundant even here. It is a coarse-structured microperthite with a varying amount of the albite component, resembling the perthite present in one of the lakarpite varieties already described. The albite of the perthite is untwinned. Indices of refraction as compared with that of kollolite indicate a very pure albite.

The microcline individuals of the pectolite-poor kaxtorpite types show no crystallographic boundaries. They further differ from the microcline just described by showing strong strain shadows which exclude the measurement of extinction angles. Otherwise they have the same appearance and show the same indices of refraction and aproximately the same axial angle 2Vα = 58°.

In distinction to the pectolite-rich kaxtorpite, the two other types ontain albite, not only in the groundmass but also as larger individuals. t is polysynthetically twinned according to the albite law and in some ndividuals pericline twins have also been observed. It shows a maximum xtinction in the symmetrical zone of 16°, corresponding with a composition of $Ab_{95}An_5$. The greater part of the large albite individuals are onperthitic but some of them contain potash feldspar in oriented interrowth. The potash feldspar of the antiperthite is always untwinned. t has the form of square-shaped spots more or less regularly distributed ver the albite individual. This structure is not unlike that of an antierthitic oligoclase in a granite pegmatite from Skåtöy, Norway, shown y Andersen (1929, Pl. IX, Fig. 3, A).

Some of the feldspar individuals show another kind of intergrowth han that here described, consisting of a core of microcline and a mantle f albite, or a core of albite and a mantle of microcline. They are thus of he same character as some of the feldspar phenocrysts of the grennaite. ndividuals with more than two zones are, however, never found, hereas in the grennaite three zones were common.

Albite is the predominant mineral of the groundmass in all three ocks of the kaxtorpite group. It occurs as elongated grains of 1—2 mm length and about 0.5 mm width. In some thin sections twinning is abundant and in others it is extremely rare. The presence or absence of twinning texture seems quite accidental. When present the twinning takes place after the albite law and the grains consist of only a few lamellae, much broader than the lamellae of the larger, polysynthetically twinned albite individuals. The extinction angle on (010) is 17°—20°, corresponding with a composition $Ab_{95}An_5$. The indices of refraction are:

α: 1.528
β: 1.532
γ: 1.539.

Microcline grains are only seldom seen in the groundmass. They are nonperthitic, show grating texture and have often strain shadows like the large microcline individuals.

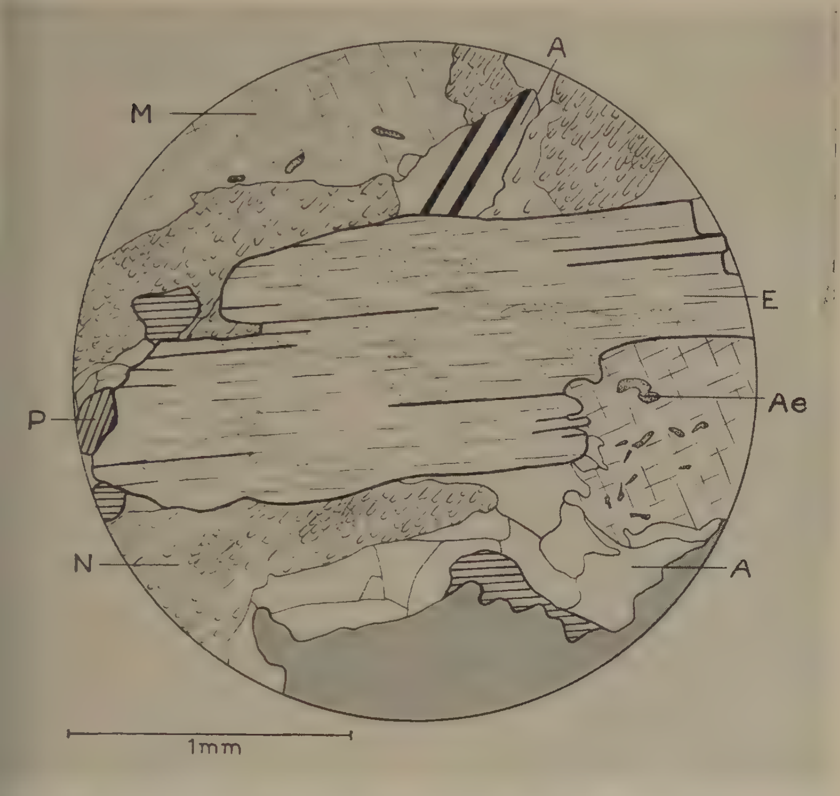
Nepheline. The nepheline grains have the same anhedral, elongated appearance as the albite grains and are of the same magnitude, 1—2 mm long. Occasionally they may form patches of several mm extension. Only one type of the pectolite-poor kaxtorpite rocks contains nepheline. It is here generally perfectly fresh, whereas the nepheline of the pectolite-rich kaxtorpite always occurs in an altered state. Sometimes the whole individual is so decomposed that it would have been impossible to identify the original mineral, if the same alteration product had not also been found in only partly decomposed nepheline crystals. The colour of the alteration product is light brown. It has a spotted appearance and a rather irregular extension in the nepheline, thus showing different degrees of decomposition. The alteration product has been isolated and analysed by R. Mauzelius with the following result (Törnebohm, 1906, p. 29):

SiO_2	46.70	Weight %
Al_2O_3	26.75	»
CaO	1.04	»
Na_2O	16.25	»
H_2O	9.26	»
	100.00	

thus identifying the mineral as natrolite.

Eckermannite. Apart from pectolite, the amphibole is the most interesting mineral of the kaxtorpite. A preliminary note on this mineral has already appeared (Adamson, 1942). Megascopically it has the appearance of black rods with high lustre, about two mm long. They have a tendency to gather in small patches and arrange themselves in narrow streaks of considerable length. These streaks surround the large microcline crystals, closely following the boundaries of the mineral.

Under the microscope it is seen that the amphibole is built up of alternating lighter and darker parts. The darker parts have a distinct



ig. 25. Eckermannite (E) in kaxtorpite. The dotted parts have lighter colours than the est of the mineral. A: albite, M: microcline, N: nepheline, Ae: aegirite, P: pectolite. Gray is kollolite. Magnification: c. 37.

leochroism in bluish green and yellowish green colours. The light arts have weaker pleochroism in paler colours. As a rule the darker oloured material constitutes the greater part of an amphibole indiidual, the light material having the character of inclusions of irregular utline and distribution (see Fig. 25). It may, however, happen that he relation is reversed, i.e. that the light material plays the dominant ole. In both cases the inclusions are intergrown in parallel orientation ith the host.

The amphibole has a very flamy extinction so that it is not possible to measure the extinction angle with any great accuracy. The darker parts show the most consistent extinction angle, the value being about 25° ($X \wedge c$), whereas the light parts show a maximum extinction angle of 53° ($X \wedge c$). Optical determinations in convergent light give the same results for both components. These observations are, however, rather uncertain owing to the imperfect interference figures caused by the low double refraction. The indices of refraction are also approximately the same, the variations lying within the limits of error of the immersion method. Nor do the two components show any perceptible difference in specific gravity. At least it is not possible to separate them by heavy liquids. Most probably there is only a slight difference in chemical composition, causing the variation in pleochroism and extinction angles. Indeed, on account of the low double refraction only a very small variation in the indices of refraction is necessary to cause a great change in the position of the indicatrix, or, as expressed by Rosenbusch-Wülfing (1925, p. 535): »Letztere (geringe Stärke der Doppelbrechung) hat namentlich zur Folge, dass die Änderungen von α, β und γ, die mit dem Wechsel der Zusammensetzung eintreten, nur klein zu sein brauchen, um doch schon grosse Änderungen in der Lage der optischen Achsen und damit auch der Auslöschungsrichtungen nach sich zu ziehen.» The results of the chemical analysis also indicate that the material is practically speaking chemically homogeneous, even if it shows some optical inhomogenities.

As to the origin of the two components, it is most probable that they crystallized simultaneously. At all events there is no evidence for the hypothesis that one of them is a secondary product from the alteration of the other.

The optical properties are as follows, the modifications mentioned above not being repeated:

The plane of the optical axes lies in the plane of symmetry. The optical orientation is therefore $Y = b$. The axial dispersion is strong with $r < v$. The optical character is negative, and the axial angle $2V\alpha = 75°$. The pleochroism is

X: bluish green, Y: light bluish green, Z: pale yellowish green, almost colourless.

$$X > Y > Z$$

The indices of refraction are:

α: 1.636
β: 1.644
γ: 1.649.

The extinction angle $X \wedge c \sim 25°$.

The combination of optical properties of this amphibole is different from all other amphiboles so far investigated. It is, however, not by virtue of its optical properties that the writer has designated this amphibole by a new name, *eckermannite.* It is far more on account of its characteristic chemical composition. It will be shown that the eckermannite occupies a natural place in the amphibole classification of Berman (1937, p. 359), which is based upon chemical and structural principles. Such a classification has a great advantage over a classification based on optical properties. Any petrologist familiar with the amphibole group will know the difficulties in giving a definite diagnosis for an amphibole on a basis of optical properties alone, particularly for a member of the hornblende series. Of course an optical study will give certain indications. Taking for instance the alkali amphiboles, they may generally be recognized by the c-axis' inclination to X, and by pleochroism in bluish colours. Any attempt at further differentiation will, however, often be in vain. Refractive index determinations, which for most minerals are of so great diagnostical value, are of little importance in such complicated compunds as the amphiboles. Considering the fact that ten elements or more may take part in the constitution of an amphibole and that substitution occurs between certain of them, it is no wonder that even chemically closely related amphiboles may show considerable variation in optical properties.

As an example may be mentioned arfvedsonite with the general formula $(Na, Ca, K)_3$ $(Mg, Fe^{II}, Mn)_4$ (Al, Fe^{III}) $(Si_4O_{11})_2$ $(O, OH, F)_2$ where the elements belonging to the respective groups indicated in the formula may substitute each other to a great extent. Here a high proportion of iron and manganese in relation to magnesium and aluminium will increase the indices of refraction, whereas a high amount of fluorine in relation to hydroxyl will lower the indices of refraction.

The variation in refractive indices will be attended by a variation in all other optical properties, for according to Kunitz: »Die Brechungsexponenten sind die wichtigsten optischen Konstanten für die Mineralbestimmung; optische Orientierung, Doppelbrechung und Auslöschungsschiefe folgen hinsichtlich Genauigkeit erst in zweiter Linie und sind, wie der optische Achsenwinkel, indirect von der Grösse und Lage der drei Brechungsindizes abhängig» (Kunitz, 1930, p. 184).

After this reservation a comparison of the optical properties of eckermannite with those of some other alkali amphiboles may be presented.

The position of the axial plane in eckermannite Y = b, is the same as for most amphiboles, except that some soda amphiboles have the axial plane at right angles to the plane of symmetry. The absorption scheme is rather peculiar, only some riebeckites, arfvedsonites and crossite showing the same relation, X > Y > Z. The colours are, however, far different from those of these amphiboles, being more like those of certain glaucophanes, which, nevertheless, have the opposite absorption scheme, Z > Y > X. The double refraction as compared with amphiboles in general is small which seems to be characteristic of the soda amphiboles (see Larsen and Berman, 1934, p. 227). The indices of refraction are much smaller than for other soda amphiboles except soda tremolite. The axial angle and the extinction angle are, however, large. Examples of amphiboles with partly similar optical properties have been listed in Table 22.

Before entering upon a discussion of the chemical composition of eckermannite, a short review of Berman's classification of the amphiboles is given. He writes as general formula for the amphibole group, representing half the content of the unit cell (1937, p. 354):

$$(WXY)_{7-8}(Z_4O_{11})_2(O, OH, F)_2$$

»The symbols W, X, Y, Z are used throughout the classification to indicate atoms of the same kind, namely atoms having given ionic radii and co-ordination numbers. The W atoms are mainly alkalies and Ca, Ba, Sr; the X atoms are divalent atoms for the most part, having intermediate radii and large co-ordination numbers; the Y atoms are trivalent or tetravalent with generally smaller ionic radii. The Z atoms are predominantly Si, with some Al in certain silicates, such as the amphiboles. The Z atoms are of small radius and have co-ordination number 4.» In the following table the elements are arranged according to their ionic radii (Goldschmidt 1926).

W	K^+	1.33 Å	$O^{2\div}$	1.32 Å
	Ca^{2+}	1.06 »	$F^{\div}$	1.33 »
	Na^+	0.98 »	$OH^{\div}$	1.4—1.5 Å
X	Mn^{2+}	0.91 »		
	Zn^{2+}	0.83 »		
	Fe^{2+}	0.83 »		
	Mg^{2+}	0.78 »		
Y	Fe^{3+}	0.67 »		
	Ti^{4+}	0.64 »		
Z	Al^{3+}	0.57 »		
	Si^{4+}	0.39 »		

Elements lying on the border between two groups may belong to both of them. This is indicated in the table by inclusion in two brackets.

Table 22.

Optical properties of certain amphiboles.

	Indices			2 V	Optical sign	Pleochroism			Orientation
	α	β	γ			X	Y	Z	
Eckermannite, Norra Kärr	1.636	1.644	1.649	75°	neg.	bluish green	light bluish green $X > Y > Z$	pale yellowish green, almost colourless	$Y = b$; $X \wedge c = 25°$ ($-53°$)
Crossite, Berkeley (Palache, 1894, p. 181)	—	—	—	—	—	deep blue	reddish blue violet $X > Y > Z$	brown to greenish yellow	$Y = b$; $X \wedge c = 13°$
Arfvedsonite, Umptek (Hackman, 1894, p. 114)	—	—	—	—	—	dunkelgrün	grauviolet, hellgelblich braun $X > Y > Z$	graubräunlich bis stahlgrau, grünlich braun	$X \wedge c = 18°$ (occasionally 40°)
Arfvedsonite-like amphibole, Kiihtelysvaara (Eskola and Sahlstein, 1930 a, p. 8)	1.670	1.680	1.682	small	neg.	dark dirty green	pale brown with a dint of greenish $Z > X > Y$	black	$Z = b$; $X \wedge c = 20°$—$25°$
Riebeckite, Gloggnitz (Graf Keyserling, 1903, p. 121)	—	—	—	great	pos.	tiefdunkelblau	blau, Stich ins Violette $X > Y > Z$	gelblichgrün, stich ins Bräunliche	$Y = b$; $X \wedge c = 1^1/_2°$—$2°$
Glaucophane, Ocha (Becke, 1880, p. 71)	—	—	—	—	—	gelbgrün, fast farblos	röthlich violett $Z > Y > X$	rein azurblau	—

Berman (p. 359) divides the amphibole group into four series: The orthorhombic anthophyllite series consisting of anthophyllite and gedrite; the cummingtonite series consisting of cummingtonite and grünerite; the tremolite-actinolite series consisting of the two species mentioned, and the hornblende series including the soda amphiboles arfvedsonite, glaucophane and riebeckite: »Within each series there is isomorphism to the extent indicated in the formulae, but between these series little overlapping is found» (p. 387).

Anthophyllite series	$X_7(Z_4O_{11})_2(OH)_2$
Cummingtonite series	$X_7(Z_4O_{11})_2(OH)_2$
Tremolite — actinolite series	$W_2X_5(Z_4O_{11})_2(OH)_2$
Hornblende series	$W_3(XY)_5(Z_4O_{11})_2(O, OH, F)_2$

The hornblende series is by far the most complex one. Berman divides the species of this series according to the distribution of the elements among the groups X and Y, as follows (p. 355):

X	Y	Si : Al	Species
5	0	7 : 1	Hornblende — edenite
4	1	6 : 2	Hastingsite
3	2	8 : 0	Glaucophane
4	1	8 : 0	Arfvedsonite

For the sake of completeness it might be added that riebeckite shows the same relations between the element groups as glaucophane. They differ, however, in the element distribution within the respective groups, the dominating X element in glaucophane being Mg and the dominating Y element Al, whereas in riebeckite they are Fe^{II} and Fe^{III} respectively.

After this introduction we shall deal with the chemistry of eckermannite. The analysis (Table 23) is computed on a basis of 24 (O, OH, F), applying a method outlined by Warren (1930, pp. 505, 515). »There are 24 (O, OH) per molecule, and as these are the largest ions, and form the body work of the structure, it is this number which is of primary importance to the structure. The amphibole analyses will therefore be discussed in terms of the number of atoms of each kind in the molecule, the number of atoms of each kind being in all cases calculated on a basis of 24 (O, OH, F).» His description of the calculation of the analysis is as follows (p. 515):

»The oxides are arranged in order of increasing radius of the metal ion. Column 1 (see Table 23) gives the per cent by weight of the oxides. Dividing column 1 by the molecular weight of the oxide, gives the relative number of oxide molecules, which is recorded in 2. Column 2 is then multiplied by the number of oxygens (fluorine) in the molecule

Table 23.

Analysis of eckermannite in kaxtorpite. Norra Kärr.

Analyst: R. Mauzelius, 1906.

		1 Weight %	2 Mol. numb.	3 Numb. of O, OH, F	4 Numb. of metal atoms and O, OH, F				5 Ideal comp.	
					a		b	c	a	b
Z	SiO_2	56.45	0.936	1.872	8.03		8.03	8.03	8	8
Y	Al_2O_3 . . .	5.47	0.054	0.162	0.92	0.96	4.34	3.99	4	1
	TiO_2	0.39	0.005	0.010	0.04					
	Fe_2O_3 . . .	9.49	0.059	0.177	1.02					1
X	MgO . . .	9.43	0.234	0.234	2.01					2
	FeO	1.90	0.026	0.026	0.22	0.35		3.96		
	ZnO	0.67	0.008	0.008	0.07					
	MnO . . .	0.52	0.007	0.007	0.06					
W	Na_2O . . .	11.30	0.182	0.182	3.12		3.61		4	4
	CaO	0.35	0.006	0.006	0.05					
	K_2O	2.41	0.026	0.026	0.44					
	H_2O	0.33	0.018	0.018	0.30		1.47	1.47	2	2
	F	2.59	0.136	0.136	1.17					
		101.30		2.864						
Less O for F . .		1.09	$\div \frac{0.136}{2} =$	0.068						
		100.21		2.796						

sp. gr. 3.16 $f = \frac{24}{2.796} = 8.58$

giving in column 3 the relative numbers of oxygen, hydroxyl and fluorine atoms contributed. From the sum of column 3 must be subtracted one half the number of fluorine atoms, since for each two fluorines there has been an additional oxygen introduced in the analysis. The corrected sum of (3) divided into 24.0 gives the ratio by which the whole analysis must be multiplied to put it on a basis of 24 (O, OH, F). Column (2) is then multiplied by this ratio, and by the number of metals in the molecule, giving in (4) the number of metal atoms of each kind on a basis of 24 (O, OH, F).»

The actual amount of Si lies as close to the theoretical as can be desired. It can therefore be taken for granted that there is no replacement of Si by Al. Between the element groups X Y and W, however, it is evident that replacement occurs to a certain extent, for the X Y-group exceeds a whole number by almost the same amount as the W-group is less than a whole number. In column 4 b Fe^{II}, Zn and Mn are included with X. They are, however, known to be interchangeable with Na, particularly Mn but also Fe^{II} and Zn in small amounts. By reckoning Fe^{II}, Zn and Mn to W (4 c), both groups come very close to whole numbers, four in each. The correct value for the OH, F content is assumed

Table 24.

Arfvedsonite from Greenland (Warren 1930, p. 513).

	Weight %	Numb. of metal atoms on a basis of 24 (O, OH, F)	
SiO_2	47.08	7.70	7.98
Al_2O_3	1.44	0.28	
TiO_2	—	—	5.10
Fe_2O_3	1.70	0.22	
MgO	—	—	
FeO	35.65	4.88	
MnO	—	—	
Na_2O	7.14	2.26	3.27
CaO	2.32	0.40	
K_2O	2.88	0.61	
H_2O	2.08	2.26	2.26
	100.29		

to be two. Considering the difficulty in the determination of water and fluorine, the difference from the ideal value is not surprising. Actually most amphibole analyses show a similiar degree of inaccuracy in the determination of these elements.

The calculation of the eckermannite analysis suggests the following general formula (5 a):

$$W_4(XY)_4(Z_4O_{11})_2(O, OH, F)_2.$$

It should be pointed out that that the sum $X + Y$ is only four, whereas in all other amphiboles known it is five. Thus this amphibole will occupy a unique position in the classification of the amphibole group, with whose general formula $(WXY)_{7-8}(Z_4O_{11})_2(O, OH, F)_2$ it is in full agreement. The deficit in XY elements is compensated by a greater amount of the W elements. The maximum alkali content of hitherto calculated amphiboles is three. Some arfvedsonites show, however, a certain excess over this value. An arfvedsonite from Greenland, mentioned by Warren (1930, p. 513) after Berwerth (Sitzber. Wiener Ak. 85, 1882, p. 168) shows one of the greatest excesses of alkali — 0.27 (see Table 24). This is explained by Warren in the following terms: ». ., a deficit in positive valence is caused by the partial replacement of Ca by alkali, and this deficit is compensated by the introduction of excess alkali, completely filling the AA′ position.» In the eckermannite the alkali (and calcium) content amounts to 3.61. The amount by which this exceeds three, 0.61, cannot, however, be regarded as an excess, for the value required in that case for the XY elements is five, but the actual amount is only 4.34, even when reckoning Fe^{II}, Zn and Mn with X.

Table 25.

Arfvedsonite from Los Archipel (Kunitz, 1930, p. 245).

Analyst: Kunitz, 1930.

		1 Weight %	2 Mol. numb.	3 Numb. of O, OH, F	4 Numb. of metal atoms and (O, OH, F)		5 Ideal comp.
Z	SiO_2	49.36	0.819	1.638	7.49	7.98	8
Y	Al_2O_3	2.78	0.027	0.081	0.49		
	TiO_2	2.12	0.027	0.054	0.25	1.20	1
	Fe_2O_3	8.24	0.052	0.156	0.95		
X	MgO	5.92	0.147	0.147	1.34	3.77	4
	FeO	18.23	0.254	0.254	2.32		
	MnO	0.86	0.012	0.012	0.11		
W	Na_2O	7.88	0.127	0.127	2.32	2.80	3
	CaO	1.83	0.033	0.033	0.30		
	K_2O	0.89	0.010	0.010	0.18		
	H_2O	2.05	0.114	0.114	2.08		2
		100.16		2.626			

$$f = \frac{24}{2.626} = 9.14$$

Reckoning them with W this group as well as the XY group amount to whole numbers, as shown in Table 23.

Study of the XY group in the calculation of the new amphibole shows that Mg is the only representative of the X elements, and that it occurs in an amount of two. Reckoning Ti with Al, the amounts of the Y elements Al and Fe^{III} are both equal to one. The formula of eckermannite may be written (see Table 23):

$$(Na, Ca, K)_3\,(Na, Fe^{II}, Zn, Mn)\,Mg_2\,Al\,Fe^{III}\,(Si_4O_{11})_2\,(O, OH, F)_2$$

or mentioning the structure-bearing elements alone:

$$Na_4\,Mg_2\,Al\,Fe^{III}\,(Si_4O_{11})_2\,(O, OH, F)_2$$

This is not only a new species, it is also a representative of a new series in the amphibole group of minerals. The general formula $W_4(XY)_4(Z_4O_{11})_2(O, OH, F)_2$ may be resolved into $W_4X_2Y_2(Z_4O_{11})_2$ $(O, OH, F)_2$. Comparing it with the other amphiboles it is evident that it follows the hornblende series in Berman's classification.

Anthophyllite series	$X_7(Z_4O_{11})_2(OH)_2$
Cummingtonite series	$X_7(Z_4O_{11})_2(OH)_2$
Tremolite—actinolite series	$W_2X_5(Z_4O_{11})_2(OH)_2$
Hornblende series	$W_3(XY)_5(Z_4O_{11})_2(O, OH, F)_2$
New series	$W_4(XY)_4(Z_4O_{11})_2(O, OH, F)_2$

A closer comparison with the related soda amphiboles, arfvedsonite, riebeckite and glaucophane will elucidate the chemical peculiarities

Table 26.

Riebeckite from Pikes Peak (Kunitz, 1930, p. 244).[1]

Analyst: Kunitz, 1930.

		1 Weight %	2 Mol. numb.	3 Numb. of (O, OH, F)	4 Numb. of metal atoms and (O, OH, F)		5 Ideal comp.
Z	SiO_2	49.46	0.820	1.640	7.9		8
Y	Al_2O_3	1.05	0.010	0.030	0.2	2.1	2
	Fe_2O_3	15.78	0.099	0.297	1.9		
X	MgO	0.62	0.015	0.015	0.1	3.1	3
	FeO	21.03	0.292	0.292	2.8		
	MnO	1.23	0.017	0.017	0.2		
W	Na_2O	8.19	0.132	0.132	2.6	2.9	3
	K_2O	1.72	0.018	0.018	0.3		
	H_2O	1.15	0.064	0.064	1.2		2
		100.23		2.505			

$$f = \frac{24}{2.505} = 9.58$$

Table 27.

Glaucophane from Zermatt (Kunitz, 1930, p. 244).

Analyst: Kunitz, 1930.

		1 Weight %	2 Mol. numb.	3 Numb. of (O, OH, F)	4 Numb. of metal atoms and (O, OH, F)		5 Ideal comp.
Z	SiO_2	57.73	0.957	1.914	7.78		8
Y	Al_2O_3	12.04	0.118	0.354	1.92	2.03	2
	Fe_2O_3	1.16	0.007	0.021	0.11		
X	MgO	13.02	0.323	0.323	2.63	3.24	3
	FeO	5.41	0.075	0.075	0.61		
W	Na_2O	6.98	0.113	0.113	1.84	2.10	2
	CaO	1.04	0.019	0.019	0.15		
	K_2O	0.68	0.007	0.007	0.11		
	H_2O	2.27	0.126	0.126	2.05		2
		100.33		2.952			

$$f = \frac{24}{2.952} = 8.13$$

of eckermannite. As representative of the arfvedsonites a species from Los Archipel, analyzed by Kunitz (1930, p. 245), was chosen (Table 25). As representative of the riebeckites a species from Pikes Peak, analyzed by Kunitz (1930, p. 244), was taken (Table 26). As representative of the glaucophanes a species from Zermatt, also analyzed by Kunitz (1930, p. 244), was selected (Table 27).

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[1] This analysis has been calculated by Berman (1930, p. 353).

Table 28.

Compilation of Columns 4 and 5 from Tables 23, 25, 26 and 27.

		Numb. of metal atoms and (O, OH, F)							
		Arfvedsonite		Riebeckite		Glaucophane		Eckermannite	
Z	SiO_2	7.49	8	7.9	8	7.78	8	8.03	8
Y	Al_2O_3	0.49		0.2	2	1.92	2	0.92	2
	TiO_2	0.25	1					0.04	
	Fe_2O_3	0.95		1.9		0.11		1.02	
X	MgO	1.34	4	0.1	3	2.63	3	2.01	2
	FeO	2.32		2.8		0.61		0.22	4
	ZnO							0.07	
	MnO	0.11		0.2				0.06	
W	Na_2O	2.32	3	2.6	3	1.84	2	3.12	
	CaO	0.30				0.15		0.05	
	K_2O	0.18		0.3		0.11		0.44	
	H_2O	2.08	2	1.2	2	2.05	2	0.30	2
	F							1.17	

The distribution of the elements within the groups W, X, Y and Z for arfvedsonite, riebeckite and glaucophane is compared with that of eckermannite in Table 28. It is seen that eckermannite is more related to riebeckite and glaucophane than to arfvedsonite, having the same amount of Y elements as the two former minerals. It differs from riebeckite in being practically devoid of ferrous iron and having a considerable magnesium and aluminium content. The difference from glaucophane is less striking, although distinct. Glaucophane contains twice as much aluminium and has only a subordinate amount of ferric iron, which amounts to one in the eckermannite formula. Finally, it is worth while to mention the remarkably high fluorine content of the eckermannite and the small content of water.

Aegirite. This mineral occurs in the form of euhedral needles or narrow laths. In the mafic streaks in kaxtorpite it is intimately intermingled with eckermannite. Aegirite is the most common inclusion in the large microcline crystals and is often seen in albite and nepheline as well.

This needle-like development of aegirite seems to be characteristic of certain alkaline rocks, e. g. the coarse-grained nepheline-syenite from Umptek as described by Hackman (1894, p. 114), the aegirite-lujavrite from Julianehaab as described by Ussing (1911, p. 166) and särnaite from Särna as described by Magnusson (1923, p. 314). The needles are elongated in the direction of the prism. The ends are often terminated by pyramidal faces but are sometimes irregularly bounded. Twinning after (100) may be seen. Pleochroism is distinct, with

X: olive green, Y: light olive green, Z: yellowish green

$X > Y > Z$.

The extinction angle is small, below 5°. Accurate measurement is rendered difficult by the smallness of the crystals and their tendency to gather in aggregates.

Pectolite. Pectolite occurs as grains of up to one mm magnitude with a brownish red colour. These generally escape attention in the dark kaxtorpite rocks, except in those comparatively rare cases when a great number of grains have gathered together. Megascopically the individuals have the appearance of rather equidimensional grains without crystallographical outlines.

Under the microscope the pectolite attracts attention by its strong interference colours. Together with eckermannite it is the most characteristic mineral of the kaxtorpite rocks. The grains are generally perfectly fresh but may contain a dark coating, particularly along cracks, which has proved to consist of manganese hydroxide (Törnebohm, 1906, p. 28). Pectolite has in general subhedral boundaries. Some grains are slightly elongated along the *b*-axis which gives them a somewhat prismatic habit. When pectolite is enclosed in nepheline, or more correctly, in the alteration product of this mineral, natrolite, it often has a euhedral development.

Pectolite was considered to have a monoclinic symmetry until Warren and Biscoe (1931), on the basis of X-ray analysis, found it to be triclinic. Morphological and optical studies carried out by Peacock (1935) on pectolite from Paterson in New Jersey proved to correspond with this result. The mineral has, however, a marked pseudomonoclinic symmetry of its optical elements which appears from the following passage referring to the Paterson pectolite (Peacock, 1935, p. 108): »The optic axial plane does not lie exactly in the *b*-axis, as required by the hitherto accepted monoclinic symmetry, but slightly inclined, so that needles lying on *a* (100) extinguish at 2° against the trace of *c* (001) while needles lying on *c* extinguish parallel to the trace of *a*. X, the obtuse bisectrix, is inclined at 10° to the *c*-axis, nearly in the acute axial angle β; the acute bisectrix, Z, is nearly in the *b*-axis.»

The Norra Kärr pectolite shows good (001) and (100) cleavages, which is common for this mineral. Sections after (001) have Z parallel to the trace of (100), showing parallel extinction, whereas in sections after (100), Z is slightly inclined to the trace of (001), showing an extinction angle of 2°. Pectolite gives a clear interference figure showing an optically positive sign and indicating a moderate axial angle. Dis-

Table 29.

Indices of refraction of various pectolites.

	1	2	3	4	5
α	1.600	1.604	1.605	1.6098	1.600
β	1.605	1.610	1.610	1.6419	
γ	1.636	1.636	1.640	1.6430	1.638

1. Pectolite from Paterson, New Jersey (Peacock, 1935).
2. Pectolite from Franklin and Sterling Hill, New Jersey (Palache, 1935).
3. Pectolite from Norra Kärr.
4. Pectolite from Schlucht Juksporlak (Kostylewa, 1925).
5. Pectolite from Mt. Khibines (Beljankin and Iwanowa, 1933).

persion is perceptible, $r > v$. Accurate measurements of the axial angle gave $2V\gamma = 35°$. Other optical constants are:

$$X \wedge c = 14°.$$

$$\alpha: 1.605$$

$$\beta: 1.610.$$

$$\gamma: 1.640.$$

The indices of refraction are only slightly different from those given by Peacock for pectolite from Paterson or from those given by Palache on pectolite from Franklin and Sterling Hill (1935, p. 65). The indices for pectolite from Schlucht Juksporlak on Mt. Khibines as determined by Kostylewa (1925, p. 383), however, deviate considerably from these values (see Table 29). The indices given by Kostylewa require an optically negative sign, whereas all other pectolites are known to be positive. Fersman (1926, p. 298), in a table of the optical properties of various Kola minerals, gives Kostylewa's indices of refraction but states the mineral to be positive. In view of the compilative character of the table, however, it may be that this statement is not based upon microscopical observation. Supposing Kostylewa's determinations to be correct, we apparently have to deal with a relation analogous to that existing be-ween eudialyte and eucolite or between positive and negative titanite, hortly to be described. However, before drawing definite conclusions as to the double character of the optical sign of pectolite, a verification f Kostylewa's results is desirable. The extreme indices of refraction of nother pectolite from Mt. Khibines determined by Beljankin and wanowa (1933, p. 327) show good agreement with the pectolite from Paterson. β is, however, not given. The optical sign of this specimen herefore cannot be estimated.

A chemical analysis of the pectolite from Norra Kärr was presented y Törnebohm (1906, p. 28) with the comment that it agreed fairly

Table 30.

Analysis of pectolite from Norra Kärr.

Analyst: R. Mauzelius, 1906.

	Weight %	Mol. numb.	Numb. of O	Numb. of metal atoms and O		
SiO_2	52.7	0.874	1.748	2.93	2.99	3
Al_2O_3	0.9	0.009	0.027	0.06		
TiO_2	0.1	0.001	0.002	0.003	0.15	
Fe_2O_3	0.6	0.004	0.012	0.03		
MgO	0.2	0.005	0.005	0.02		
MnO	2.2	0.031	0.031	0.10		
Na_2O	9.1	0.147	0.147	0.98	0.98	1
ΣLa_2O_3	0.3	0.003	0.009	0.02	1.82 (1.97)	2
CaO	29.9	0.533	0.533	1.79		
K_2O	0.1	0.001	0.001	0.01		
H_2O	3.1	0.172	0.172	1.15		1
	99.2		2.687			

$$f = \frac{9}{2.687} = 3.35$$

well with the analysis of manganese-pectolite from Magnet Cove, Arkansas as given by Williams (1891, p. 386). This analysis was computed on a basis of nine oxygen atoms in the formula, taking half the content of the unit cell (Warren and Biscoe, 1931, p. 400). The analysis (Table 30) is seen to be in very good agreement with the formula $Ca_2NaHSi_3O_9$, reckoning manganese and the other elements of minor importance with calcium as suggested by the formula of the isomorphous schizolite $(Ca, Mn)_2NaHSi_3O_9$.

In Table 31 a compilation of pectolite analyses from different localities has been made. Manganese is able to substitute calcium to a smaller or greater extent and occurs in varying proportions in the different analyses. The specimens from Norra Kärr, Franklin and Sterling Hill, and Magnet Cove obviously represent transitional members between pure pectolite $Ca_2NaHSi_3O_9$, and schizolite $(Ca, Mn)_2NaHSi_3O_9$. For comparison a schizolite analysis is given (column 8 in Table 31).

Titanite. This mineral is the most abundant of the accessories. It occurs as wedge-shaped grains of 0.2—0.4 mm diameter. They are usually intermingled with the mafic constituents, more seldom they are surrounded by albite and nepheline. In the latter case they have a tendency to collect, sometimes forming patches one mm or more in diameter. The colour is light brown with no perceptible pleochroism. Other grains are paler, almost colourless.

In the two pectolite-poor kaxtorpite types all grains are optically positive as titanite is known to be. In the pectolite-rich type, however,

Table 31.

	1	2	3	4	5	6	7	8
SiO_2	52.7	52.04	53.80	53.03	53.80	52.24	54.32	51.06
Al_2O_3	0.9	0.92	0.00	—	2.06			
TiO_2	0.1				trace			0.62
Fe_2O_3	0.6		0.00	0.10	0.95		0.11	
MgO	0.2	0.05	0.00	—	trace			
FeO		1.29	1.00		—	(+MnO) 1.75		2.74
ZnO		0.26						
MnO	2.2	2.31	0.12	4.25	0.55			9.84
Na_2O	9.1	7.97	9.01	8.99	7.38	(+K_2O) 8.48	9.32	9.97
ΣLa_2O_3	0.3				—			ΣY_2O_3 1.03 ΣCe_2O_3 0.94
CaO	29.9	31.15	33.20	30.28	32.01	33.83	34.00	22.89
SrO		0.12			—			
BaO		0.13			—			
K_2O	0.1	0.90	0.00		[1] 0.59			
CO_2				0.82	—		trace	
H_2O	3.1	3.07	2.94	2.43	2.85	3.70	2.55	0.55
	99.2	100.21	100.07	99.90	100.22	100.00	100.30	99.64

. Pectolite from Norra Kärr. Törnebohm, 1906, p. 28.
. Pectolite from Franklin and Sterling Hill. Palache, 1935, p. 66. Analyst: R. B. Gage.
. Pectolite from Paterson, New Jersey. Peacock, 1935, p. 109. Analyst: F. A. Gonyer.
. Pectolite from Magnet Cove, Arkansas. Williams, 1891, p. 386. Analyst: Williams.
. Pectolite from Schlucht Juksporlak. Kostylewa, 1925. (Ref. Fersman, 1929, p. 40). Analyst: N. P. Wrewskaja.
. Pectolite from Långban. Igelström, 1859, p. 400. Analyst: Igelström.
. Pectolite from Niakornat, Greenland. Böggild, 1905, p. 389. Analyst: Chr. Christensen.
. Schizolite from Kangedluarsuk, Greenland. Böggild, 1904, p. 136. Analyst: Chr. Christensen.

n examination of the different grains revealed the puzzling feature hat some of the grains were optically negative. A mere inspection of he thin sections does not indicate that there is any difference in optical roperties between the different individuals. All grains have quite the ame appearance, and it has proved impossible to distinguish the two inds of titanite when an interference figure is unobtainable. Dispersion strong $r > v$, more pronounced in the negative mineral than in the ositive. Otherwise there is no fundamental difference in the optical roperties of the two varieties. The double refraction is, however, maller for both varieties than for titanite in general. Törnebohm (1906, . 29) gives a rather extensive description of the negative titanite, but e has apparently failed to observe the positive titanite in the pectolite-ch kaxtorpite type (described as a lakarpite type in Törnebohm's sense this term), at least he does not mention it, although he has recorded ositive titanite in the other kaxtorpite types.

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[1] There is a small difference in the K_2O content of this analysis as reported in N. J. 26 II, p. 317 (K_2O: 0.53) and by Fersman (1929, p. 40). Here Fersman's figure is gi-n. The original paper has not been seen.

It was thought that in certain parts of the pectolite-rich kaxtorpite area there might be a concentration of one kind of titanite at the expense of the other. Several thin sections from different outcrops were examined. Positive and negative titanite occurred, however, side by side in all of them with only accidental variation in the distribution. Positive and negative titanite with a similiar mode of occurrence has been mentioned by von Eckermann from urtite and ijolite on Alnö (1942, pp. 418, 443). He suggests that the difference in optical orientation may depend upon the presence of lanthanides.

Apatite. Apatite occurs as small, generally euhedral grains of about 0.1 mm diameter. It is usually found together with aegirite and eckermannite but is only seldom included in the amphibole.

Fluorite. Fluorite occurs as interstitial masses between the other minerals. It is only rarely found in the pectolite-rich kaxtorpite type but is more abundant in the two pectolite-poor types.

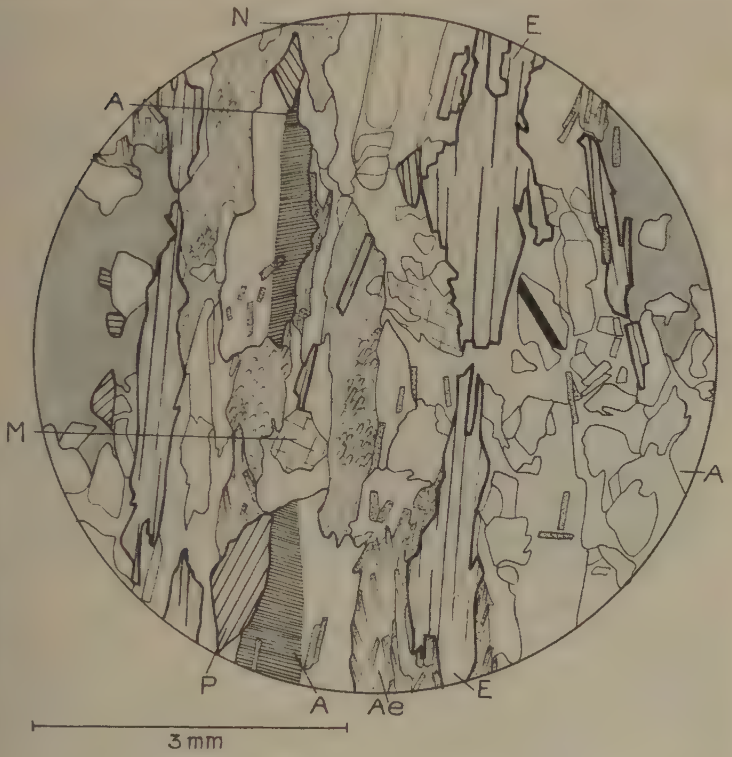
c. Petrographical Character.

The chief minerals of the kaxtorpite rocks are: microcline, albite (in part perthitic), nepheline (more or less decomposed into natrolite), eckermannite, aegirite and pectolite. Titanite, apatite and fluorite are present only in accessory anounts. As a secondary mineral prehnite is occasionally found.

We shall first deal with the pectolite-rich kaxtorpite (kaxtorpite 1), which belongs to the nepheline-syenite family. The most conspicuous, megascopic feature of this rock is the large, glassy microcline crystals (Fig. 23). They show a certain variation both in magnitude and in abundance. They may vary from five mm to two cm in length. The microcline crystals are distinctly crystallographically bounded by and evidently belong to a generation other than that of the feldspar of the groundmass. The groundmass minerals generally have a grain diameter between one and two mm, but the aegirite needles are smaller, only 0.2—0.3 mm long.

Under the microscope it is seen that microcline only rarely occurs in the groundmass. Here the most abundant feldspar is albite, very often untwinned. Nepheline is rather irregularly distributed, some thin sections being quite rich in this mineral, whereas others may be almost devoid of it. The relative amounts of aegirite and eckermannite are subject to certain variations, though eckermannite is in general predominant. Like nepheline, pectolite also shows a tendency to accumulate in certain parts of the rock. Some thin sections may contain as much as ten per cent of pectolite whereas others may not have more than three per cent.

The texture of the groundmass can be seen from Fig. 26. Albite and nepheline usually form anhedral, oval individuals. The aegirite needles will in general gather in aggregates, often associated with eckermannite



ig. 26. Groundmass of kaxtorpite (type 1). A: albite, M: microcline, N: nepheline, partly tered into natrolite, Ae: aegirite, E: eckermannite, P: pectolite. Magnification: c. 13.

hich generally occurs in isolated laths. Pectolite is euhedrally bounded gainst albite and nepheline and often occurs as inclusions in the latter ineral, having, particularly in this case, crystallographic boundaries. may also be found as inclusions in the large microcline crystals to-ther with aegirite and titanite. Pectolite shows, however, evidently hedral boundaries against aegirite and eckermannite. Apparent der inclusions of pectolite in eckermannite have proved to belong adjacent pectolite grains which have crystallized later and pierced the eckermannite. Titanite is occasionally found as inclusions in pectolite.

The two other kaxtorpite types (kaxtorpite 2 a and 2 b) differ from the type first dealt with in certain respects. For instance, the large well-bounded microcline crystals are lacking in these rocks; they only contain about five mm large, irregularly bounded microcline and albite individuals, often perthitic. Microscopic examination shows that these individuals have jagged and granulated boundaries, sometimes being intersected by lines of inclusions. The albite often has inclusions of aegirite and eckermannite. Both rocks have an indistinctly porphyritic appearance. Pectolite only occurs in subordinate amounts but is nevertheless a characteristic constituent. Fluorite is more abundant than in the first type. In some thin sections a few grains of an isotropic mineral with low index of refraction, which may be sodalite, are seen.

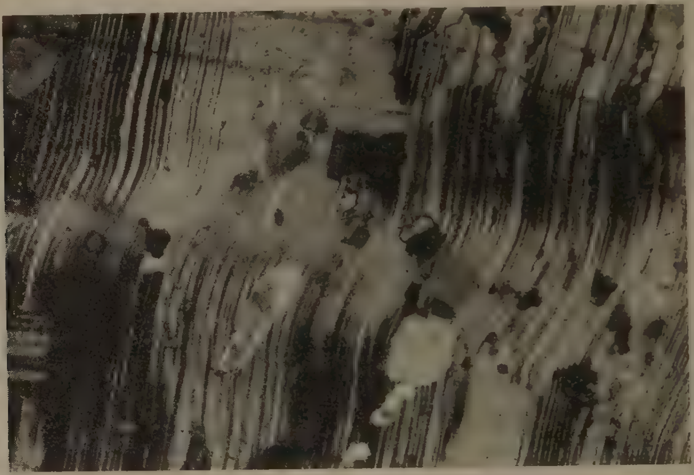


Fig. 27. Polysynthetically twinned albite showing protoclastic deformation. Kaxtorpite, type 2 b. Magnification: 100.

Between themselves the two last mentioned types differ in the content of nepheline and in that of mafic minerals as can be studied in Tables 33 and 34. The mafic minerals, aegirite and eckermannite, have otherwise the same habit and the same mode of occurrence in all three kaxtorpite types, and this is also the case with the other minerals of the groundmass.

As was mentioned in the previous chapter, the kaxtorpite rocks were in the main schistose, only the pectolite-poor nepheline-bearing kaxtorpite (kaxtorpite 2 a) having in part a massive development. Under the microscope it can be seen that the massive rock shows evidence of cataclastic deformation such as strain shadows in the microcline and peripheral crushing of the larger feldspar grains. The schistose rocks show the same features but also show indications of protoclastic deformation, the twin lamellae of the polysynthetically twinned albite individuals being folded, as seen in Fig. 27.

The most extraordinary feature of the kaxtorpite rocks, which are not very rich in lime, is undoubtedly the circumstance that pectolite occurs in essential amounts and seems to appear as a primary mineral, euhedrally bounded with the feldspars and nepheline, but anhedrally bounded with aegirite and amphibole.

The most common mode of occurrence of pectolite is in certain basic rocks together with zeolitic minerals, e.g. as described by Schwartz (1925, p. 83) in a diabase from Pigeon Point in Minnesota where pectolite, xonotlite and prehnite occur as secondary products, or by Walker and Parsons (1926, p. 15) in a diabase from Lake Nipijon, Ontario, together with analcite, prehnite and scapolite as cavity fillings, or by Böggild (1905, p. 388) in basalt from Niakornat in Greenland. Pectolite may also occur in connection with contact-metamorphosed limestones, e.g. on Gjellebekk near Oslo (Warren and Biscoe, 1931 p. 400[1]), or in Franklin where pectolite is grouped with the pegmatite contact minerals following the deposition of the zinc ores (Palache, 1929 a; see the table facing p. 20). Pectolite has a similiar mode of occurrence at Långban (Palache 1929 b, p. 43).

Pectolite has been considered to be a typical low temperature mineral. When it was previously observed as an accessory constituent of certain alkaline rocks, it was taken as evidence of hydrothermal activity e.g. by Kranck (1928, p. 85) who referred to the results of Koenigsberger and Müller (1921, p. 433) which under certain conditions gave a stability range for pectolite between 330° C and 360° C. Williams (1890, p. 386) has described manganese pectolite in a eudialyte-bearing nepheline-syenite from Magnet Cove. It is here a secondary mineral formed at the expense of eudialyte and aegirite. Brouwer (1910, p. 129) has described a mineral which he supposed to be pectolite in a eucolite lujavrite occurring near Wijdhoek in Transvaal. This mineral is regarded as a late crystallization product having anhedral boundaries with feldspar and nepheline.

Very little is written in West European languages concerning the mineral association of pectolite in the alkaline rocks of the Kola Peninsula. Fersman in one paper states that it occurs in nepheline-syenite pegmatites together with yuksporite and neptunite (Polkanov, 1937, p. 100), and in another he says: »It (pectolite) occurs in large masses in gneissic pegmatites or nephelite syenites. Numerous analyses show it to possess a variable composition. It is accompanied by sphene, fibrous astrophyllite, aegirite, biotite, natrolite, and more rarely by grains of fluorite, galena and sphalerite» (Fersman 1926, p. 294).

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[1] According to a private communication from Professor V. M. Goldschmidt the mineral had here previously been taken for wollastonite, until X-ray examinations proved it to be pectolite.

As appears from the foregoing remarks the mode of occurrence of pectolite in kaxtorpite is quite different from the modes of occurrence described. It is difficult to find a plausible explanation for the formation of pectolite in kaxtorpite. There is nothing in the chemical composition of the kaxtorpite rocks indicating that they contain such a calcium-rich mineral as pectolite. It is remarkable that the content of lime in the kaxtorpite analyses has entered the pectolite almost quantitatively, leaving the amphibole, which shows euhedral boundaries with pectolite, and the plagioclase, which shows anhedral boundaries with pectolite, virtually calcium-free (see Table 23 and p. 194). The formation of pectolite in these rocks must be due to quite peculiar physicochemical conditions during the crystallization. It is probable that volatile constituents have played an important role.

d. Chemical Composition.

From the chemical analysis (Table 32) it is seen that the kaxtorpite type 1 is of a highly sodic character, even if not so sodic as the lakarpite. The preponderance of alkalis over aluminium is sufficient to place the rock in the agpaite subgroup of the nepheline-syenite family (see p. 180), the relation $\frac{na + k}{al}$ being 1.3. In distinction to the Greenland members of this subgroup, the kaxtorpite is, however, devoid of zirconium.

A characteristic feature is that by far the greater part of the iron content is present as ferric iron. The ferrous iron is just sufficient to bind the titanium available for the formation of normative ilmenite, thus leaving the norm free of magnetite. The eckermannite is represented in the norm mostly by acmite, whereas the amphibole of the lakarpite appeared as diopside and olivine components (Table 18). Thus from the norms we can recognize an essential difference between the chemical characters of the two amphiboles, the eckermannite exclusively containing ferric iron, which is also verified by the mineral analysis (Table 23), whereas ferrous iron must be predominant in the amphibole of the lakarpite.

The content of aluminium is insufficient to form normative anorthite. Owing to the low aluminium content, the excess of calcium in the norm after the formation of apatite enters wollastonite, which in the norm represents the pectolite of the mode.

Table 32.

Analysis of pectolite-rich kaxtorpite (1), Norra Kärr.

Analyst: Grosser, 1935 (Tröger, 1935, p. 169).

	Weight %	10 000 M	Norm		Mode Vol.%		Niggli's system	
SiO_2	57.72	9 572	Or	23.28	Albite		qz	÷ 60
TiO_2	0.87	109	Ab	35.03	$Ab_{95}An_5$	22	si	184
Al_2O_3	14.28	1 397	Nef	8.94	Microcline		ti	2.1
Fe_2O_3	4.96	311	Σsal	67.25	$Kf_{78}Naf_{21}$		p	1.0
FeO	0.74	103			Rbf_1	31		
MnO	0.07	10	wo	5.51	Nepheline	12	al	27.0
MgO	2.29	568	en	5.71	Ecker-		fm	24.5
CaO	3.62	645	ac	14.21	mannite	19	c	12.5
Na_2O	9.07	1 463	Na_2SiO_3	2.15	Aegirite	5	alk	36.0
K_2O	3.93	417	il	1.66	Pectolite	8		
P_2O_5	0.74	52	mt	0.09	Titanite	2	mg	0.44
CO_2	0.02	5	ap	1.70	Apatite	1	k	0.22
$H_2O > 105°$	1.58		Σfem	31.03		100	c/fm	0.35
$H_2O < 105°$	0.04							
	99.93		H_2O	1.62				
			CO_2	0.02				
				99.92				

Quantitative System: II : 6 (5) : 1 : 4, Lardalose (Umptekose).

Table 33.

Analysis of pectolite-poor kaxtorpite with nepheline (2 a), Norra Kärr.

Analyst: Thelma Berggren, 1943.

	Weight %	10 000 M	Norm		Mode Vol%		Niggli's system	
SiO_2	58.95	9 776	Or	22.94	Albite		qz	÷ 44
TiO_2	0.97	121	Ab	49.87	$Ab_{95}An_5$	37	si	194
ZrO_2	0.04	3	Nef	5.44	Microcline	31	ti	2.41
Al_2O_3	15.84	1 550	Hl	0.81	Nepheline	10	zr	0.06
Fe_2O_3	3.63	227	Z	0.05	Ecker-		p	0.44
FeO	1.44	200	Σsal	79.11	mannite	7		
MnO	0.16	23			Aegirite	9	al	30.8
MgO	1.75	434	wo	3.88	Pectolite	2	fm	22.1
CaO	3.51	626	en	4.37	Titanite	2	c	12.7
SrO	0.05	5	ac	5.46	Apatite	1	alk	34.4
BaO	0.07	5	hm	0.11	Fluorite	1		
Na_2O	8.17	1 318	il	1.84		100	mg	0.39
K_2O	3.87	411	mt	2.37			k	0.24
P_2O_5	0.32	22	ap	0.76				
SO_3	0.00		fl	2.25			c/fm	0.57
$H_2O > 105°$	0.53		Σ fem	21.04				
$H_2O < 105°$	0.13							
F	0.91	478	H_2O	0.66				
Cl	0.51	144		100.81				
	100.85							
Less O for F, Cl	0.51							
	100.34							

Quantitative System: II : 5 : 1 : 4, Umptekose.

Table 34.

Analysis of pectolite-poor kaxtorpite without nepheline (2 b), Norra Kärr.

Analyst: Thelma Berggren, 1942.

	Weight %	10000 M	Norm		Mode	Vol %	Niggli's system	
SiO_2	63.14	10 471	Q	1.98	Albite		qz	+ 15
TiO_2	0.62	77	Or	30.70	$Ab_{95}An_5$	47	si	243
ZrO_2	0.34	28	Ab	54.76	Microcline	37	ti	1.79
Al_2O_3	16.26	1 591	Hl	0.03	Eckermannite	5	zr	0.65
Fe_2O_3	2.40	150	Z	0.51				
FeO	1.25	174			Aegirite	7	al	37.0
			Σsal	87.98				
MnO	0.20	28			Pectolite	2	fm	17.5
MgO	1.04	258	wo	1.55	Titanite	1.5	c	6.0
CaO	1.39	248	en	2.60	Fluorite	0.5	alk	39.5
SrO	0.01	1	ac	1.16		100		
BaO	0.04	3	Na_2SiO_3	0.97			mg	0.34
Na_2O	7.11	1 147	il	1.18			k	0.32
K_2O	5.18	550	mt	2.91				
P_2O_5	0.04	3	ap	0.11			c/fm	0.34
SO_3	0.00		fl	1.04				
$H_2O > 105°$	0.63							
			Σfem	11.52				
$H_2O < 105°$	0.14							
F	0.42	221	H_2O	0.77				
Cl	0.03	9						
				100.27				
	100.24							
Less O for F, Cl	0.19							
	100.05							

Quantitative System: I : 5 : 1 : 4, Nordmarkose.

When calculated to which order of the quantitative system the kaxtorpite 1 belongs, it is found to lie on the border between orders 6 and 5, lendofelic and perfelic. The position of the rock is therefore between II : 6 : 1 : 4, Lardalose and II : 5 : 1 : 4, Umptekose.

The kaxtorpite type 2 a (Table 33) is not so sodic as type 1 but otherwise all essential chemical features such as the aluminium, calcium, and magnesium contents, the ratio between ferrous and ferric iron and that between sodium and potassium are in agreement. In the quantitative system the rock belongs decidedly to the umptekose subrang, its position being II : 5 : 1 : 4, Umptekose. It is however richer in alkalis than the rocks generally referred to as umptekite, pulaskite or any petrographical term covering rocks related to these. Petrographically it must be said to belong to the nepheline-syenites, but it approaches the pulaskite group (Johannsen, 1938, p. 5).

The norm indicates a considerable sodium content in the microcline, as it does for the kaxtorpite type 1 (where it was verified by analysis of the microcline), the Table 33 showing much less modal albite than

Table 35.

	1	2
SiO_2	63.14	63.68
TiO_2	0.62	0.80
ZrO_2	0.34	0.02
Al_2O_3	16.26	17.37
Fe_2O_3	2.40	2.17
FeO	1.25	1.39
MnO	0.20	0.16
MgO	1.04	0.68
CaO	1.39	1.16
SrO	0.01	—
BaO	0.04	0.04
Na_2O	7.11	6.50
K_2O	5.18	5.77
P_2O_5	0.04	0.10
SO_3	0.00	
$H_2O > 105°$	0.63	0.38
$H_2O < 105°$	0.14	0.07
F	0.42	n. d.
Cl	0.03	n. d.
	100.24	100.32

. Pectolite-poor kaxtorpite without nepheline (type 2 b), Norra Kärr.
. Mean of twelve analyses of nordmarkites from the Oslo district (Brögger, 1933, p. 87), including CO_2 : 0.01 and S : 0.02.

ormative soda feldspar and at the same time much more modal micro- line than normative potash feldspar.

A remarkable feature of the kaxtorpite type 2 a is the high amount f chlorine which necessitates the introduction of halite in the norm, he content of phosphorous being insufficient to satisfy the chlorine ontent in the formation of normative apatite. Sodalite is only found as rare accessory and can by no means account for so much as 0.81 per ent NaCl. The only mineral of the rock which can be imagined to ontain a certain amount of chlorine is eckermannite.

The amount of normative fluorite is also amazingly great compared ith the content of this mineral actually present in the rock, even if e allow a certain amount of fluorine to enter the eckermannite (see able 23). Fluorite is, however, very irregularly distributed in the rock nd the specimen selected for analysis probably happened to be one xceptionally rich in this mineral.

The kaxtorpite type 2 b (Table 34) is decidedly more acid than the wo other types. The norm even contains a certain amount of quartz. o quartz has, however, been detected under the microscope. The rock hows the same characteristic chemical relations as the two other axtorpite types, which appears both from the norm and from Niggli's ystem.

In the quantitative system the rock has the position I : 5 : 1 : 4, Nordmarkose, thus having order, rang and subrang analogous to those of the kaxtorpite type 2 a and only differing from this rock in the relation between salic and femic minerals. This places it in Class 1.

The analysis resembles very much that of nordmarkite from the Oslo district. In Table 35 the mean values of twelve analyses of nordmarkites from the Oslo district as given by Brögger (1933, p. 87) can be compared with the kaxtorpite type 2 b from Norra Kärr. All figures except that of ZrO_2 lie within the limits of variation of the nordmarkite analyses. The zirconium belongs, however, to katapleite which is derived from the grennaite. This circumstance is due to the fact that the marginal part of the area containing the kaxtorpite type 2 b was to a certain extent mixed with grennaitic material, and it is only this marginal part which is exposed, as appears from the description of the field observations (p. 192). The normal kaxtorpite rocks are zirconium-free as has been pointed out previously (see p. 188).

V. Fenitization of the Surrounding Granite.

As was mentioned on p. 119 the Växiö granite surrounding the Norra Kärr district is transformed into syenitic and quartz-syenitic rocks at a distance of up to 100 metres from the contact. We have a fenitization zone, to use a term well known in Scandinavia. The word fenite, first used by Brögger (1921, p. 156), is used in the sense emphasized by von Eckermann (1942, p. 402): ». . . med fenit måste avses huvudsakligen in situ metasomatiskt, med eller utan substansutbyte, omvandlade kontaktanslutande bergarter, och icke mobiliserade och transporterade hybrida blandbergarter[1].»

The fenite rocks around the Norra Kärr district have retained the structural features of the granite and grade so gradually into this rock that it is not possible to determine the width of the fenitization in the field. The variations are, however, readily studied under the microscope. It can be seen that the width of fenitization is not the same in all directions. It is at the most 100 metres, often only 50 and never less than 25 metres. On the whole it seems that the fenitization has reached further to the west of the Norra Kärr district than to the east.

The intensity of the fenitization decreases radially from the grennaite border. There may however be certain irregularities, different fenite types being found at equal distances from the contact. It is someimes difficult to say to what extent the variations are due to initial nhomogenities in the granite, since the Växiö granite may contain basic egregations which it is not always possible to recognize when they are ltered by the fenitization processes. The characteristic features of he fenitization will appear from the following description of a radial ection on the western side of the Norra Kärr district.

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[1] ». . . by fenite should be understood contact rocks altered metasomatically mainly *in situ*, with or without exchange of material, but not mobilized and transported hybrid rocks.»

100 metres from the contact, the granite is altogether uninfluenced. t consists essentially of undulating quartz, microcline perthite, turbid lagioclase (due to sericitization), and biotite as described on p. 119. he first sign of fenitization is a decrease in the amount of quartz and a ecrystallization of the microcline perthite, beginning in the peripheral arts of the crystals. The bands of perthitic albite are completely assimilated. No kind of perthitic texture is visible in the recrystallized microcline with moderate magnification. At higher magnification, however, a fine perthitic texture is seen, resembling the film perthite described by Andersen (1929, p. 154), probably the result of later »Entmischung» due to a decrease in the temperature after the assimilation of the albite bands. The recrystallized microcline show a somewhat finer grating texture than the original mineral. Hand in hand with the recrystallization of the microcline perthite a recrystallization of the quartz has also taken place. The recrystallized quartz is not undulating and occurs as blebs of various sizes in the recrystallized microcline. Sometimes only a couple of quartz blebs in each microcline individual are to be seen but there may be as many as a dozen. They form a kind of runitic (graphic granite) intergrowth with the microcline, all blebs having uniform optical orientation. In a few microcline individuals two series of uniformly oriented quartz blebs have been observed. Some 30 metres from the contact quartz has completely disappeared.

When the recrystallization of the microcline perthite has proceeded o some extent, an incipient recrystallization of the turbid plagioclase an be observed, starting from the margins and grading concentrically owards the centres of the individuals. They are transformed into perfectly fresh albite material, generally polysynthetically twinned after he albite law. The maximum extinction angle in the symmetrical zone s 14°, corresponding to a composition $Ab_{92}An_8$. Apart from the recrystallized individuals, albite is also found in another mode of occurrence, amely as aggregates of smaller grains, consisting of two or three albite wins, occurring interstitially between the larger crystals. There is onsiderably more albite in the fenite rocks than there was in the original ranite, and the content of albite has increased by approximately he same amount as that of quartz has decreased. The smaller albite rains are probably newly formed, and represent the material which has substituted the quartz. The textural features of the fenite rocks show, however, no evidence of such substitution.

About ten metres from the contact it is seen that the recrystallized microcline is replaced to a certain extent by albite, forming a marginal zone around a core of microcline. The albite is then developed with a peculiar chessboard texture. The optical orientation of the microcline has been induced in the albite, the twins following the albite law, being parallel in both minerals. Sometimes a coarse perthitic texture has arisen. In a few cases nearly the whole microcline individual is replaced, only a small residue of the original mineral being left in the centre. The microcline often contains a certain amount of sericite which has been deposited preferentially along cracks in the microcline.

About 5 metres from the contact the rock is more intensely fenitized than in the outer fenite zones, which can be seen from the mode of occurrence of the feldspars. By far the greater part of the albite material occurs in coarse perthitic intergrowth with microcline, and many of the isolated albite individuals show evidence of protoclastic deformation. The perthitic albite usually comprises the greater part of an individual, which therefore ought to be termed an antiperthite. The texture of this antiperthite resembles that of the interlocking perthite described by Andersen (1929, p. 181) more than anything and can hardly be attributed any other mode of origin than simultaneous crystallization of the two components. The feldspar material of the granite must be supposed to have mixed rather thoroughly before the two components separated again upon cooling. The perthitic albite is generally constituted of broad twin lamellae, twinned according to the albite law, and the microcline shows a fine grating texture. The microcline has an extinction angle of 18° on (001) and 4° on (010), whereas the albite has an extinction angle of 4° on (001) and 18° on (010), indicating very pure microcline and albite respectively.

In the outer fenite zones the biotite shows no signs of alteration. About 5 metres from the contact, however, it is gradually substituted by aegirite. All grades of alteration can be observed, from the incipient resorption of a biotite flake until its complete transformation into aegirite. In the Växiö granite, several biotite flakes are sometimes seen to occur in clusters, often together with grains of magnetite and titanite. In those cases one large aegirite individual may have been formed comprising all the biotite flakes, which then can be seen as more or less resorbed inclusions in the aegirite. To a considerable extent aegirite also forms small grains occurring interstitially between the feldspar grains. The smaller aegirite grains all have an extinction angle of $X \wedge c = 2°—3°$, indicating a very pure aegirite, whereas the larger individuals which have originated from a number of biotite flakes often show a zonal growth with extinction angle $X \wedge c = 10^\circ$ in the centre and $X \wedge c = 2^\circ$—3° in the margin, indicating a somewhat augitic core. The aegirite shows pleochroism in yellowish green colours. This aegirite-bearing fenite occurring near the contact is more mafic than the other fenite types with undecomposed biotite.

Narrow bands of fluorite, some millimetres broad and very irregularly distributed, are found throughout the fenite zone, in particular near the contact.

In one piece of rock of the aegirite-bearing fenite, a few grains of a mineral have been observed for which it has not been possible to make a satisfactory diagnosis. I have not been able to rediscover the mineral, though much seeking in the rock where it was discovered. It is found in association with biotite and aegirite and has an interstitial mode of occurrence. The mineral has megascopically a grayish green colour. The largest grain is about three mm long. Under the microscope it is seen that the mineral is not perfectly fresh, being in general covered with a turbid material with somewhat lower index of refraction than the fresh mineral. The first grains which were examined gave the illusion that the mineral was isotropic. A couple of grains proved, however, to have a certain birefringence, about 0.002. In some grains a very indistinct axial figure may be obtained, which seems to have an uniaxial character. The index of refraction is great, about 1.760. These data are insufficient to determine the mineral with any certainty. It is hoped that more material will be found, which will allow a closer examination of this interesting mineral.

The chemical composition of the aegirite-bearing fenite appears in Table 36. The analysis has been carried out on a specimen taken one metre from the contact with the Norra Kärr district. The rock is seen to be of nordmarkitic composition, containing as much as 3.97 per cent normative quartz. No quartz is, however, seen in the thin sections. On the other hand, the aegirite actually present in the rock is not represented by acmite in the norm, all sodium of the analysis being used up by the formation of albite. There is even Al_2O_3 left after the formation of anorthite, which has to be reckoned as corundum. The normative corundum stands for the sericite in the mode. The amount of corundum in the norm is however greater than might be expected from the actual amount of sericite in the rock. It is probable that the specimen chosen for analysis happened to contain a greater amount of sericite than usual.

The analysis shows a certain content of CO_2 corresponding to 0.73 per cent calcite in the norm. No calcite or other CO_2-bearing minerals

Table 36.

Analysis of aegirite-bearing fenite, one metre from the border. Norra Kärr.

Analyst: Astri Thorkildsen, 1943.

	Weight %	10 000 M	Norm		Mode	Vol %	Niggli's system	
SiO_2	61.70	10 232	Q	3.97	Microcline	32	qz	+30
TiO_2	0.20	25	Or	27.80	Albite mainly perthitic)	54	si	273
Al_2O_3	21.20	2 074	Ab	55.12			ti	0.58
Fe_2O_3	1.48	93	An	0.17			p	0.12
FeO	2.37	330	C	5.33	Sericite	5		
MnO	0.03	4	Σsal	92.39	Aegirite	5	al	48.1
MgO	0.29	72			Biotite	4	fm	13.8
CaO	0.53	95	en	0.72		100	c	2.2
Na_2O	6.50	1 048	fs	2.81			alk	35.9
K_2O	4.69	498	il	0.38				
CO_2	0.32	73	mt	2.16			mg	0.12
P_2O_5	0.07	5	ap	0.17			k	0.32
H_2O	0.75		pr	0.04				
S	0.02	6	cc	0.73			c/fm	0.16
	100.15		Σfem	7.01				
			H_2O	0.75				
				100.15				

Quantitative System: I : 5 : 1 : 4, Nordmarkose.

could, however, be detected under the microscope. Probably the analyzed specimen contained some secondary calcite which may have been deposited along cracks in the rock.

In the quantitative system the aegirite-bearing fenite has the position I : 5 : 1 : 4, Nordmarkose.

In summing up the above observations, it may be said that the fenitization of the Växiö granite around the Norra Kärr district shows a maximum extension of 100 metres and that it consists in a disappearance of quartz and a recrystallization of the feldspars of the granite, together with a new formation of albite which partly replaces the microcline. In the last period of fenitization the biotite nearest to the contact has been altered into aegirite-augite and aegirite. Except for the decomposition of biotite, there is a gradual variation in the mineralogical composition of the fenite zone, the granite being gradually transformed into quartz-syenitic and syenitic rocks as we approach the contact, representing an increasing degree of fenitization.

The alteration of the Växiö granite is best explained by the supposition that there has been a migration of volatile materials into the granite, combined with a removal of material dissolved from the granite, very much in the same way as described from Fen and Alnö by Brögger

Table 37.

	1	2	3	4
SiO_2	56.75	55.06	61.70	75.12
TiO_2	0.03	0.002	0.20	0.25
ZrO_2	1.60	1.04		
Al_2O_3	21.10	24.86	21.20	12.23
Fe_2O_3	2.29	0.26	1.48	0.96
FeO	0.23	0.48	2.37	1.34
MnO	0.12	0.018	0.03	0.07
MgO	0.08	0.04	0.29	0.53
CaO	0.76	0.12	0.53	0.84
BaO		0.00		0.04
Na_2O	11.66	12.46	6.50	3.18
K_2O	3.88	4.45	4.69	5.14
CO_2			0.32	
P_2O_5	0.01	0.00	0.07	0.07
H_2O	1.69	1.27	0.75	0.49
Cl	0.04			
S	0.03	0.01	0.02	0.01
	100.27	100.07	100.15	100.27
Q			3.97	33.72
Or	23.00	26.35	27.80	30.48
Ab	37.08	28.67	55.12	26.98
An			0.17	3.82
Nef	26.99	40.30		
Hl	0.07			
Z	2.40	1.56		
C			5.33	0.01
Σ sal	89.54	96.88	92.39	95.01
wo	1.55	0.24		
en	0.20	0.03	0.72	1.33
fs		0.24	2.81	1.39
fo		0.05		
fa		0.37		
ac	4.72			
Na_2SiO_3	1.48	0.61		
il	0.06		0.38	0.47
mt	0.95	0.37	2.16	1.39
ap	0.03		0.17	0.17
pr	0.06	0.01	0.04	0.02
cc			0.73	
Σ fem	9.05	1.92	7.01	4.77
H_2O	1.69	1.27	0.75	0.49
	100.28	100.07	100.15	100.27

1. Analysis and norm of normal grennaite, Norra Kärr (see p. 145).
2. Analysis and norm of marginal facies of grennaite, Norra Kärr (see p. 149).
3. Analysis and norm of aegirite-bearing fenite, Norra Kärr (1 metre from the contact) (see p. 222).
4. Analysis and norm of normal Växiö granite (see p. 120).

(1921) and von Eckermann (1942) respectively, leading to a metasomatosis of the original granite into fenitic rocks.

To facilitate the chemical study of the fenitization processes Table 37 has been compiled, comprising analyses and norms of normal grennaite, marginal facies of grennaite, aegirite-bearing fenite and normal Växiö granite. The quartz-bearing fenite can be estimated to have a composition intermediate between those of aegirite-bearing fenite and Växiö granite, except for iron, which is present in approximately the same amount as in the Växiö granite.

Comparing the analyses of the fenite with that of the granite it is seen that the main processes of the fenitization have been a removal of SiO_2 (and K_2O to some extent) and an addition of Al_2O_3 and Na_2O. The decrease of SiO_2 on part of the fenite as compared with the granite is approximately compensated by the increase of Al_2O_3 and Na_2O. We thus have had an exchange of material, SiO_2 moving from the granite towards the alkaline body and Al_2O_3 and Na_2O from the alkaline body towards the granite. Very little can be said about the character of the chemical compounds, by means of which the exchange of the above mentioned elements has taken place. The bands of fluorite found throughout the fenite zone may indicate that silicon was carried off as SiF_4. The great amount of albite in the fenite as compared with that in the granite (see the norms in Table 37) may be explained by the supposition that the SiO_2, dissolved from the quartz, has been added to sodium aluminate solutions derived from the alkaline body, approximately according to the equation:

$$Na_2Al_2O_4 + 6SiO_2 \rightarrow 2NaAlSi_3O_8.$$

It is also probable that the formation of sericite in the fenite is due to the supply of Al_2O_3. The process may have taken place according to the equation:

$$KAlSi_3O_8 + Al_2O_3 + H_2O \rightarrow KAl_3Si_3O_{10}(OH)_2$$

In considering the aegirite-bearing fenite nearest the contact, we must also deal with the increase in the amount of iron as compared with that in granite. The presence of aegirite in the fenite is not in harmony with the chemical composition of the rock (Table 36), the formation of aegirite demanding a deficit of aluminium in relation to sodium, whereas the analysis shows an excess of aluminium. As long as the ratio $Al_2O_3 : Na_2O$ is greater than 1 albite will be formed; not until this ratio is below 1 can the formation of aegirite be expected.

A comparison of the white marginal facies of grennaite with normal grennaite gives a clue to the problem. The essential difference between

Table 38.

Main chemical variations in the fenite zones of Fen, Alnö and Norra Kärr.

	Fen	Alnö	Norra Kärr	
			first stage	second stage
removed	SiO_2	$SiO_2 + H_2O$	SiO_2	SiO_2
	K_2O	Na_2O	(K_2O)[1]	
introduced	Na_2O	K_2O	Na_2O	Na_2O
	Al_2O_3		Al_2O_3	
	Fe_2O_3	Fe_2O_3 (TiO_2)		Fe_2O_3
	CaO	CaO		
	CO_2	CO_2		

the two rocks (columns 1 and 2, Table 37) is seen to be the iron content, almost all the aegirite having disappeared from the marginal facies of grennaite. Under the description of this rock (p. 148) it was suggested that the aegirite material lacking here had migrated into the surrounding rock. This supposition is verified by the formation of aegirite in the fenite nearest the contact (column 3, Table 37), involving an enrichment of iron.

It seems that there have been two stages in the fenitization; firstly an extensive sodium-aluminium metasomatosis influencing the light minerals of the granite, but towards which the biotite was stable, secondly a sodium-iron metasomatosis leading to the decomposition of biotite and the formation of aegirite nearest the contact. This sodium-iron metasomatosis probably took place in connection with the solidification of grennaite.

A comparison is made below with the fenite zones of two other alkaline districts in Scandinavia, namely Fen (Brögger, 1921, p. 173) and Alnö v. Eckermann, 1942, p. 432). The element variation in the fenite zone of Norra Kärr is compared in Table 38 with those of these two districts.

The fenite zones of Fen and Alnö are clearly distinguished from that of Norra Kärr by the role played by CaO and CO_2 in the fenitization. CO_2 is particularly important as its influence upon the pressure conditions probably had no counterpart during the fenitization around the alkaline body of Norra Kärr. With respect to the conveyance of the other elements Norra Kärr has more in common with Fen than with Alnö, as can be seen from the table.

Comparing the mineralogical variations in the fenite zone of Norra Kärr with that of Fen, it shows as close a resemblance as could be expected from the chemical relations. Brögger's description of the influence of fenitization upon the feldspars in Fen (1921, p. 169) could be applied to similar features of the Norra Kärr district almost without corrections, the alterations at both places starting with a recrystallization of the potash feldspar, followed by a recrystallization of the plagioclase, in part replacing the potash feldspar, and a new formation of albite. The essential difference between the fenite zones of Fen and Norra Kärr is the mode of occurrence of aegirite. Both in Fen and in Alnö one of the first signs of fenitization is the formation of aegirite at the expense of biotite. It starts even before the content of quartz has begun to decrease. In Norra Kärr, on the other hand, biotite is altogether stable during the first stages of fenitization. It is not decomposed until quite near the contact, long after the last remnants of quartz have disappeared.

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[1] The brackets around K_2O in the Norra Kärr column indicate that it has been removed in subordinate amounts only.

It is tempting to associate the stability of biotite at Norra Kärr with the absence of CaO and CO_2 which has made the physicochemical conditions quite different from those prevailing during the fenitization around the Fen and Alnö districts. Von Eckermann, in his preliminary description of the Alnö district (1942, p. 435), has in some detail given an account of the chemical reactions leading to the formation of aegirite. He has also touched upon the dissociation of the carbonates and its importance in the fenitization.

VI. Relationship of the Rocks.

1. Chemical Relationship.

In the subjoined tables (39, a, b, c) six chemical analyses are presented together with their norms and Niggli values, representing the principal variations in rock composition within the Norra Kärr district.

All rocks are seen to have certain chemical characters in common, such as an abundance of alkalis in relation to lime and great predominance of sodium over potassium. The range of potassium is very small, all analyses containing about four per cent. The total amount of iron is low and is subject only to small variations. The rocks are further characterized by a negligible amount of manganese. Carbon dioxide is altogether absent. There is a deficiency of silica in all rocks except kaxtorpite 2 b which contains a certain amount of normative quartz.

The consanguinity of the rocks is clearly demonstrated by their position in the quantitative system as appears from Table 40. All rocks are seen to be peralkalic and dosodic, belonging to rang 1 and subrang 4.

Table 39 a.

Analyses of the main rocks of the Norra Kärr district.

	1	2	3	4	5	6
SiO_2	52.04	58.89	57.72	58.95	63.14	56.75
TiO_2	0.90	0.24	0.87	0.97	0.62	0.03
ZrO_2	0.24	0.15		0.04	0.34	1.60
Al_2O_3	15.73	17.34	14.28	15.84	16.26	21.10
Fe_2O_3	2.84	2.77	4.96	3.63	2.40	2.29
FeO	4.27	2.13	0.74	1.44	1.25	0.23
MnO	0.26	0.16	0.07	0.16	0.20	0.12
MgO	2.79	1.56	2.29	1.75	1.04	0.08
CaO	4.66	4.22	3.62	3.51	1.39	0.76
BaO		0.48		0.07	0.04	
SrO				0.05	0.01	
Na_2O	10.17	6.72	9.07	8.17	7.11	11.66
K_2O	3.84	4.00	3.93	3.87	5.18	3.88
P_2O_5	0.84	0.32	0.74	0.32	0.04	0.01
SO_3				0.00	0.00	
CO_2			0.02			
$H_2O > 105°$	0.62	0.52	1.58	0.53	0.63	1.69
$H_2O < 105°$	0.14	0.15	0.04	0.13	0.14	
F	0.51	0.08		0.91	0.42	
Cl	0.06	0.19		0.51	0.03	0.04
S		0.17				0.03
Pb		0.14				
	99.91	100.23	99.93	100.85	100.24	100.27

1. Lakarpite, 2. Pulaskite, 3. Kaxtorpite 1, 4. Kaxtorpite 2 a, 5. Kaxtorpite 2 b, 6. Grennaite with phenocrysts of katapleite.

They are enclosed in the two classes I, persalane and II, dosalane. In each class only the orders 5, perfelic and 6, lendofelic are represented.

Grennaite is more salic than the phanerocrystalline rocks, four of which belong to class II, dosalane, whereas the fifth falls into class I, persalane, together with grennaite. Grennaite is however clearly distinguished from this rock as well as from the other phanerocrystalline rocks by a number of qualities not expressed in the quantitative system. The most conspicuous of these is perhaps the ratio between zirconium and titanium, grennaite showing extremely high content of zirconium and being virtually devoid of titanium, whereas the phanerocrystalline rocks all have high contents of titanium and little or no zirconium. Of the other minor constituents we find that the phanerocrystalline rocks have an almost uniformly high content of magnesium and phosphorus which are present only in trifling amounts in grennaite. With respect to the major constituents, grennaite shows a considerable enrichment of sodium and alumina as compared with the phanerocrystalline rocks. It also has a much higher ratio between ferric iron and ferrous iron, the latter only being present in almost negligible amounts.

Table 39 b.

Norms of the main rocks of the Norra Kärr district.
Key as in Table 39 a.

	1	2	3	4	5	6
Q					1.98	
Or	22.77	23.72	23.28	22.94	30.70	23.00
Ab	27.46	48.38	35.03	49.87	54.76	37.08
An		5.66				
Nef	17.34	4.34	8.94	5.44		26.99
Z	0.37	0.22		0.05	0.51	2.40
Hl		0.20		0.81	0.03	0.07
Σ sal	67.94	82.52	67.25	79.11	87.98	89.54
wo	6.10	5.92	5.51	3.88	1.55	1.55
en	3.53	3.89	5.71	4.37	2.60	0.20
fs	2.28	1.27				
fo	2.40					
fa	1.71					
ac			14.21	5.46	1.16	4.72
Na$_2$SiO$_3$	6.23		2.15		0.97	1.48
il	1.70	0.46	1.66	1.84	1.18	0.06
mt	4.12	4.02	0.09	2.37	2.91	0.95
hm				0.11		
ap	2.07	0.83	1.70	0.76	0.11	0.03
fl	1.06	0.20		2.25	1.04	
pr		0.27				0.06
PbS		0.19				
Σ fem	31.20	17.05	31.03	21.04	11.52	9.05
H$_2$O	0.76	0.67	1.62	0.66	0.77	1.69
CO$_2$			0.02			
	99.90	100.24	99.92	100.81	100.27	100.28

Table 39 c.

The Niggli values of the main rocks of the Norra Kärr district.
Key as in Table 39 a.

	1	2	3	4	5	6
qz	÷ 92	÷ 34	÷ 60	÷ 44	+ 15	÷ 95
si	142	186	184	194	243	194
ti	2.1	0.58	2.1	2.41	1.79	0.08
zr	0.33	0.23	0.0	0.06	0.65	2.68
p	0.97	0.44	1.0	0.44	0.05	0.02
al	25.2	33.5	27.0	30.8	37.0	42.6
fm	27.5	21.0	24.5	22.1	17.5	7.3
c	13.7	15.5	12.5	12.7	6.0	2.8
alk	33.6	30.0	36.0	34.4	39.5	47.3
mg	0.41	0.37	0.44	0.39	0.34	0.06
k	0.20	0.28	0.22	0.24	0.32	0.18
c/fm	0.50	0.70	0.35	0.57	0.34	0.38

Table 40.

The position of the rocks: grennaite, lakarpite, pulaskite, kaxtorpite 1, kaxtorpite 2a and kaxtorpite 2b in the quantitative system.

	Class I. Persalane		Class II. Dosalane	
Order	5. Perfelic Canadare	6. Lendofelic Russare	5. Perfelic Germanare	6. Lendofelic Norgare
Rang 1. Peralkalic	Nordmarkase	Miaskase	Umptekase	Lardalase
Subrang 1.				
Subrang 2.				
Subrang 3.				
Subrang 4. Dosodic	Nordmarkose	Miaskose	Umptekose	Lardalose
Subrang 5.				

The singular character of grennaite as compared with the phanerocrystalline rocks appears from the description above. However, even if the phanerocrystalline rocks have certain characters in common distinguishing them from grennaite, they also show considerable variation among themselves within certain limits.

In analogy with Washington's terminology as applied to the Roman comagmatic region (1906, p. 145), the chemical characters which were common for all the Norra Kärr rocks could be called *absolute characters* as distinct from the *serial characters*. »Superposed on these absolute characters, . . . are the characters which may be called *serial*, and which consist in a definite variation in the amounts of one or more constituents concomitant with a variation in one or more others, which variations may be either in the same or opposite direction.» (Washington, 1906, p. 148.) It is, however, not possible to trace any continual serial variation throughout all the rocks of the Norra Kärr district and not even throughout the phanerocrystalline rocks. Only within the kaxtorpite group are the serial characters recognizable. Here it is een that we have a decrease in ferric iron and an increase in ferrous ron as silica increases. At the same time aluminium increases and potassium also shows a rising tendency, whereas sodium, calcium and magnesium decrease. As regards the minor constituents, phosphorus decreases with increasing silicon as does titanium.

From the Niggli values it is seen that the pulaskite differs in one ssential respect from the other rocks. It has *al* $>$ *alk* whereas all other ocks have *al* $<$ *alk*. This is also apparent from the norm, pulaskite ontaining normative anorthite. The amount of anorthite is not, however, sufficient to distinguish it from the other rocks in the quantitative system. It still falls under Umptekose in rang 1, but approaches Akerose in rang 2.

It has been mentioned that the high zirconium content of grennaite is one of its most characteristic qualities. The phanerocrystalline rocks may also be characterized according to their zirconium content, lakarpite and pulaskite containing a certain amount of this element, whereas it is altogether absent or present in negligible amounts in the kaxtorpite rocks.[1]

The main chemical variations of the Norra Kärr rocks can be studied in the Niggli diagrams in Fig. 28. In order to study the variations in greater detail, three other diagrams were plotted.

Most of the rocks show scarcely any variation in the silica percentages. The commonly used variation diagrams, where the other oxides are plotted against silica, are therefore not practicable. For rocks with irregular variation in silica, Larsen (1938) has proposed a new diagram. Studying some petrographical provinces in the western United States he arrived at the result (p. 506) that it was better to determine the position of a rock on the basis of all its variable major constituents. »In the plots advocated in this paper, the position of the analysis is determined by the sum of one-third SiO_2 and K_2O minus the sum of the MgO, CaO and total iron calculated as FeO, or one-third $SiO_2 + K_2O \div MgO \div CaO \div FeO$.» This idea is applied in the two diagrams of the Norra Kärr rocks in Figs. 29 and 30, with the one difference that K_2O is substituted by Na_2O since K_2O is here nearly constant whereas Na_2O shows considerable variation.

In the variation diagram of Fig. 29 the positions of the rocks are characterized by the sums of CaO, MgO and FeO, which oxides are largely confined to the mafic minerals. The points are seen to lie almost along a smooth curve, which shows a marked decrease from lakarpite to grennaite. In Fig. 30 the single oxides are plotted against the same abscissa values. It is here seen that only the points for FeO, MgO and CaO fall nearly on smooth curves. All the other oxides, except K_2O which is nearly constant, show an irregular variation.

Larsen (1938) has also constructed a very instructive triangular diagram (Fig. 31), or more correctly, two diagrams, of which the one is superposed upon the other. They are based upon a modification of the norms of the rocks.

»For the first plot the normative feldspar of the rock (in silica-deficient rocks feldspathoids are calculated to feldspar) is calculated to 100

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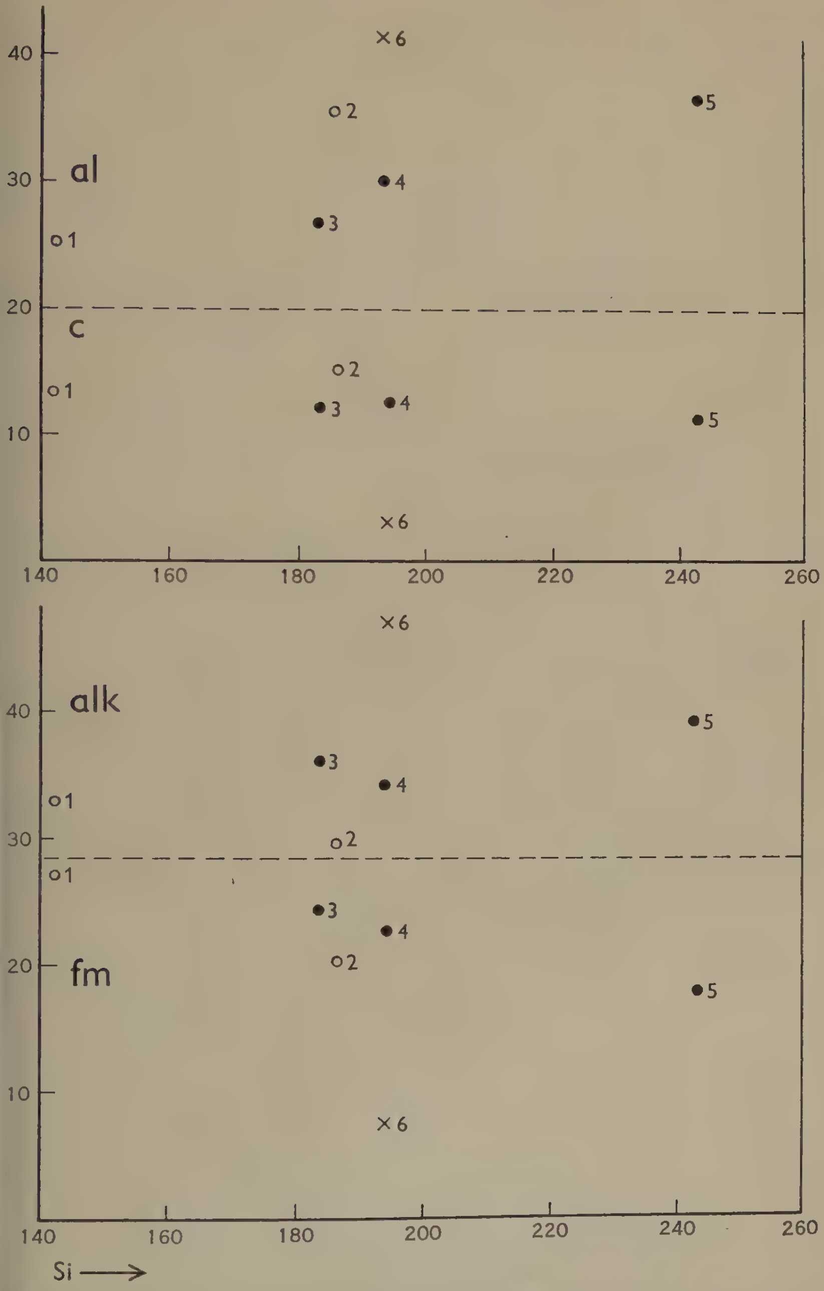
[1] As was pointed out on p. 218 the content of zirconium found in the analysis of kaxtorpite 2b is due to katapleite derived from the grennaite.



ig. 28. Niggli diagrams of the rocks of the Norra Kärr district. The figures refer to able 39 a. Lakarpite and pulaskite are marked with open circles, the kaxtorpites rocks with solid circles and grennaite with a cross.

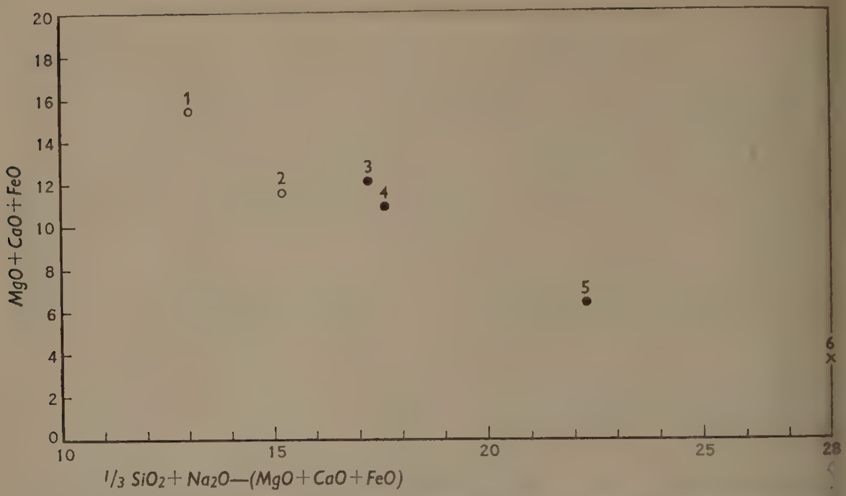
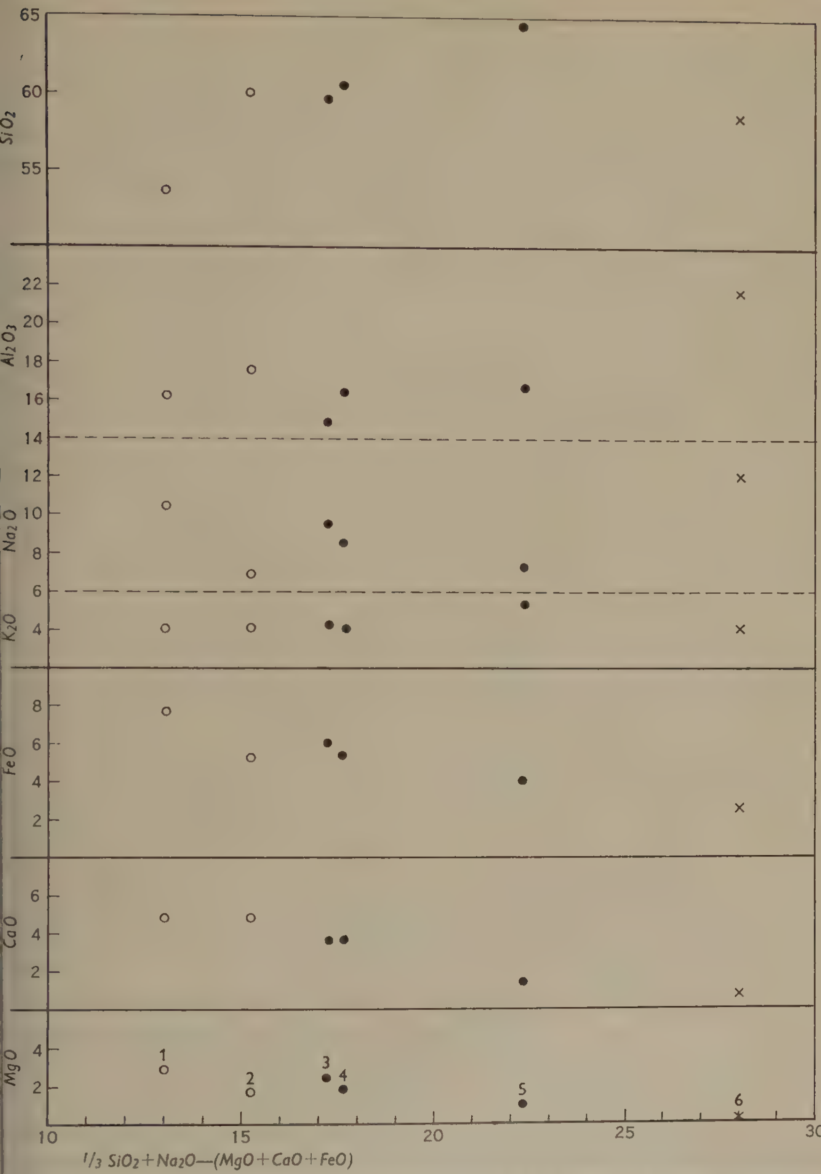


Fig. 29. The relation between $^1/_3$ $SiO_2 + Na_2O$: $(MgO + CaO + FeO)$ and $MgO + CaO + FeO$ for rocks of the Norra Kärr district. The figures refer to Table 39 a.

per cent and or, ab and an are plotted. To do this, the normative nepheline is multiplied by 1.845 and added to the albite, . . .»

»For the second plot the normative quartz, feldspar and femic minerals are calculated to 100 per cent and plotted.» The normative olivine is converted to pyroxene by multiplying it by 1.40 and the feldspathoids are calculated to feldspars as in the first plot. »The amount of SiO_2 added to olivine, nepheline and leucite to yield pyroxene and feldspar is the SiO_2 deficiency. Where there is deficient SiO_2, the sum of the feldspar and femic minerals is 100 per cent. SiO_2 is placed on the lower left of the diagram, feldspar on the lower right and femic minerals at the top. To plot deficient SiO_2, the base of the diagram is extended to the right and a parallel line at the upper apex of the diagram is drawn. In this area beyond the triangle the position along a line parallel to the right side of the triangle represents the proportions of feldspar and femic minerals and the distance of this line from the edge of the triangle represents the deficiency in SiO_2.» (Larsen, 1938, p. 516.)

We thus have obtained two groups of values: or — ab — an, and: deficient SiO_2 (or quartz) — feldspar — femic. »To show as many of the characters of the rocks as possible, these two groups of values are plotted together on a triangular diagram, and the two points for each analysis joined by a line. The resulting plot shows the Na_2O, K_2O, and CaO of the feldspar and feldspathoids, the oversaturation or undersaturation of the rock, and the proportion of femic minerals in the rock.» (Larsen, p. 516.)



ig. 30. Variation diagram for the rocks of the Norra Kärr district. Abscissa as in Fig. 29. The figures refer to Table 39 a.

Plots of this kind for the rocks from the Norra Kärr district are hown in Fig. 31. The diagram demonstrates clearly most of the charac eristic features of the rocks, their peculiarities as well as their relation hips.

Table 41.

List of the most important minerals of the Norra Kärr rocks, mentioned in order of their abundance in the respective rocks.

Rock name	Dark minerals, zirconium minerals and pectolite included	Light minerals
Lakarpite II: 6: 1: 4, Lardalose	Arfvedsonite Rosenbuschite	Albite ($Ab_{92}An_8$) Nepheline Microcline
Pulaskite II: 5: 1: 4, Umptekose	Aegirite ($X \wedge c = 8°—10°$) Soda amphibole Biotite Rosenbuschite	Microcline Albite ($Ab_{93}An_7$) Nepheline
Kaxtorpite 1 II: 6 (5): 1: 4, Lardalose (Umptekose)	Eckermannite Pectolite Aegirite	Microcline ($Naf_{21}Kf_{78}Rbf_1$) Albite ($Ab_{95}An_5$) Nepheline
Kaxtorpite 2 a II: 5: 1: 4, Umptekose	Aegirite Eckermannite Pectolite	Albite ($Ab_{95}An_5$) Microcline Nepheline
Kaxtorpite 2 b I: 5: 1: 4, Nordmarkose	Aegirite Eckermannite Pectolite	Albite ($Ab_{95}An_5$) Microcline
Grennaite I: 6: 1: 4, Miaskose	Aegirite Eudialyte Katapleite	Anorthoclase ($Naf_{75}Kf_{24}$) Nepheline

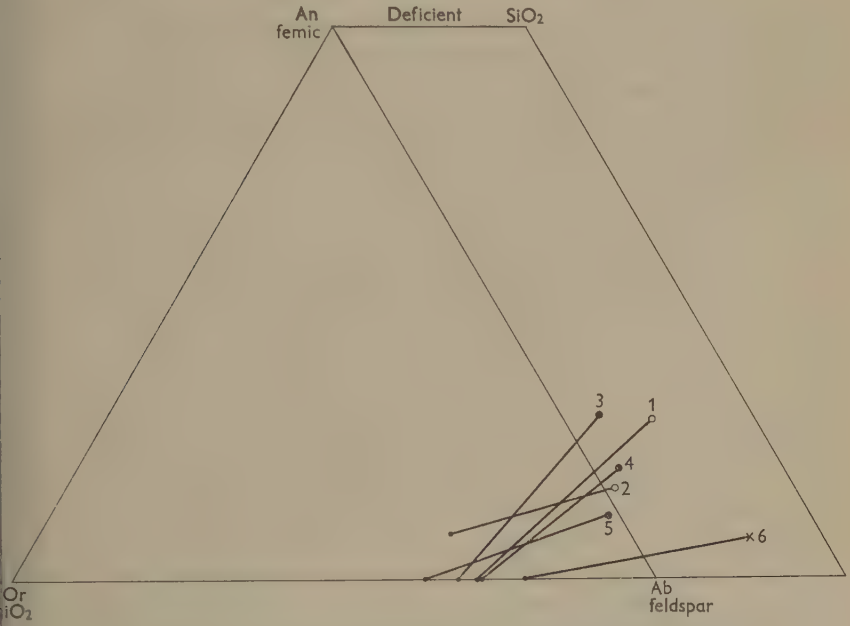
2. Mineralogical Relationship.

In Table 41 is given a list of the most important minerals of the Norra Kärr rocks. In all the phanerocrystalline rocks there can be distinguished two kinds of feldspar: microcline with quadrille twinning texture and albite, most often twinned after the albite law, but sometimes untwinned. A very characteristic feature is that the feldspars are in general non-perthitic. Microcline perthite and antiperthite are occasionally met with and they then occur together. The microcline contains, however, a certain amount of soda feldspar in solid solution. The composition of the microcline in kaxtorpite was determined to be $Naf_{21}Kf_{78}Rbf_1$.

Anorthoclase is characteristic of grennaite. It was found to have the composition $Naf_{75}Kf_{24}$.

Nepheline is present in all rocks except kaxtorpite 2 b. There is generally a close agreement between its normative and modal amounts.

Eckermannite and pectolite are seen to be characteristic of the axtorpite rocks. The aegirite of these rocks is also characteristic, aving quite another habit than the aegirite of the grennaite and that f the pulaskite. The aegirite of the pulaskite is not quite pure, showing n extinction angle X $\wedge$ c = 8°—10°, whereas the aegirites of the ther rocks have an extinction angle X $\wedge$ c = 2°—4°.



ig. 31. Triangular diagram for the rocks of the Norra Kärr district. Dots refer to the r-ab-an-triangle. Open circles, solid circles and cross refer to the quartz (deficient SiO_2)-ldspar-femic-triangle and signify lakarpite and pulaskite, the kaxtorpite rocks and grennaite respectively.

Pulaskite is the only rock containing biotite.

The Norra Kärr rocks contain two decidedly different soda amphioles, arfvedsonite and eckermannite, of which arfvedsonite shows a redominance of ferrous over ferric iron and eckermannite predominance f ferric over ferrous iron. The ratios of ferric iron to ferrous iron in the nalyses of the respective rocks strikingly reflect this difference in the hemistry of the two minerals. The amphibole of the pulaskite has opical properties intermediate between those of arfvedsonite and eckerannite.

An interesting mineralogical feature of the Norra Kärr rocks is the ccurrence of pectolite and rosenbuschite. They are both extremely calcium-rich silicates showing certain structural similarities (Peacock, 1937, p. 26), and essentially differing chemically only in the zirconium content of the rosenbuschite, as can be seen from the following, somewhat idealized formulae:

Pectolite:	$Ca_2NaHSi_3O_9$
Rosenbuschite:	$Ca_2Na(Zr, Ti)Si_2O_8F$

Pectolite is only found in the kaxtorpite rocks and is associated with aegirite and eckermannite. Rosenbuschite is found in lakarpite and pulaskite and is associated with arfvedsonite.

Katapleite and eudialyte are characteristic of grennaite. These minerals are indicative of high zirconium concentration and high alkali concentration.

VII. Discussion of the Observations.

1. Geological Observations.

The Norra Kärr district has an oval form and is sharply bounded. The surrounding granite is altered into quartz-syenitic and syenitic rocks forming a fenite zone around the district. The main rock, grennaite, is generally schistose and then shows a structure which conforms perfectly with the contact line against the fenite zone. Grennaite shows a generally vertical or almost vertical foliation. The fact that the structure of grennaite conforms with the outer boundaries of the district must be considered as sufficient evidence for a precrystalline character of the schistosity. This fact seems to indicate that the grennaite crystallized out of a magma intruding into the Växiö granite. Before proceeding to discuss the mode of intrusion of the grennaite, a short account of some geological features of alkaline rocks in general will be given.

A considerable number of alkaline districts are described as having a circular or oval form. They are characterized by names such as plug, stock, pipe or volcanic neck, expressing the general conception of their manner of intrusion. The two latter names imply that the alkaline body had connection with the surface during its solidification, but the two former names not necessarily so. The terms plug and stock differ in dimensions, plug being confined to very small bodies only. Some alkaline districts are referred to as laccoliths (e. g. Pilansberg as described by Shand, 1928) in order to emphasize that the magma is supposed to have crystallized under the surface.

The geological structures of alkaline bodies intersecting crystalline ocks are generally not accessible for closer study. When they show a de- ree of resistance to erosion similar to that of the surrounding rocks, they re exposed at one level only. Only in the case of some greater occur- ences such as the Umptek massif, has the body itself been dissected by rosion. However, when the body has intersected limestones, sandstones r shales, the erosion has in the course of time removed the country ock at a greater speed than the rocks of the alkaline body, the latter orming a hill or a mountain elevated above the surrounding landscape.

Even in well exposed districts, however, it is usually impossible to et up criteria which would unequivocally prove a certain manner of ntrusion. There are only few alkaline bodies showing conclusive evidence n this respect. We have indisputable examples of volcanic vents fil- ed with alkaline rocks such as the Leeuwfontein and Leeuwkraal plugs n Pretoria, containing soda-trachytes and phonolites (Shand, 1922 a), nd Katzenbuckel in Odenwald, the main rock of which was referred to s »Nephelinbasalt» by Freudenberg (1906, p. 205) and as »Sanidin- ephelinit» by Nieland (1932), the latter term being defined as (p. 97) Effusivformen theralitischer (ijolitischer) Magmen von meso- bis helanokratem Habitus». We have also indisputable examples of non- olcanic alkaline bodies, such as the Shonkin Sag laccolith of the Highwood Mountains in Montana, where the alkaline body has retained ts original cover of sedimentary rock (Weed and Pirsson, 1895, . 399).

The geological relations of most alkaline districts do not permit general onclusions as to their manner of intrusion. One hypothesis is generally ccepted because it »puts a much smaller strain on the probabilities», o quote a phrase used by Shand (1928, p. 149) than other hypotheses onsidered. Sometimes a district is interpreted as a more or less deep- eated section through a volcanic neck, and sometimes the alkaline body referred to as a plug or a stock.

To return to the Norra Kärr district, the geological relations of hich appear in the accompanying map, it seems to meet all the require- ents generally demanded of a section through a volcanic neck or a lug. The vertical foliation of the grennaite supports such an interpre- tion. The district is elongated parallel to the schistosity of the sur- unding Växiö granite, which was probably a direction of smaller sistance in the rock. An eruption intersecting the granite might there- re be expected to attain such a form as the Norra Kärr district.

One of the most fascinating problems of the district is the interpre- tion of the peculiar texture of the grennaite. This texture as described n p. 142 and as seen from Figs. 9 and 10 gives more the impression of belonging to a crystalline schist than to an igneous rock (as was pointed out by Törnebohm, 1906, p. 7) reminding of the gneisses of nepheline-syenitic composition from Mt. Cevadaes in Portugal, described by Osann (1907, p. 109). However, paying no regard to the schistosity, the texture could be characterized as aplitic, being xenomorphic granular. Among the alkaline rocks such a texture is most commonly found in exceptionally broad tinguaitic dykes. Tinguaite of this texture may, in fact, show considerable resemblance to grennaite, as appears from the following description of tinguaite by Rosenbusch (1907, p. 619): »Die zumal in den mächtigeren Gängen herrschende Struktur[1] hat entschieden aplitischen Character. Dabei bilden Feldspat und Nephelin ein entweder panidiomorphkörniges oder ein allotriomorphkörniges Aggregat von sehr gleichbleibenden und gleichen Dimensionen beider und die Ägirinnadeln liegen in und zwischen beiden, oder geben durch parallele Anordnung dem Ganzen trotz der richtungslosen Mengung der beiden Hauptkomponenten einen fluidalen Habitus.» A tinguaitic ring-dyke of Pilansberg, described by Shand (1928, p. 136) shows a textural facies which also seems to correspond to grennaite, and in Idding's textbook on igneous rocks, grennaite (catapleiite-syenite) is actually said to have »tinguaitic habit» (1913, p. 243).

There is unfortunately only a small difference in level within the Norra Kärr district, so the geological structure of the rock mass cannot be submitted to a closer study, which would probably have contributed to the solution of the problem of the textural development of grennaite. It may, however, be that the mode of occurrence of two textural equivalents to grennaite has a bearing upon the problem. We shall therefore describe the mode of occurrence of these rocks at some length.

Under the description of latite-phonolites from the volcanic area of the Cripple Creek district, Lindgren and Ransome (1906) discuss »granular rocks closely resembling and connected by textural gradations with the latite-phonolites». Concerning the development of the different textures, they say (p. 85): »The nature of the two groups of rocks (viz. granular rocks and latite-phonolites) and their manner of occurrence make it probable that only a slight difference in conditions, such as change of temperature or pressure, or minor variations in composition, were needed to cause the one or the other to crystallize from the magma. There is little or no evidence available to show that the granular rock is the deep-seated equivalent of the porphyritic. The transition from the one to the other is apparently regardless of distance from the surface or from contacts. It is probable that these granular rocks have formed

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[1] It should be pointed out that »Struktur» here is identical with »texture» in the sense with which this term has been applied in the present paper.

uch nearer the surface than is believed usually to be the case, for
rosion since the volcanic period does not appear to have been very
reat. It seems likely, in fact, that some of these rocks solidified within
few hundred feet of the surface. It is possible that the rocks
to which they were intruded were then at a high temperature and
hat the cooling was consequently slower than it would otherwise
ave been.»

In his description of the phonolite (apachite) from the Apache Mts.
West Texas, Osann has also described some rocks from the Mt. Ord
ange not far from the Apache Mts. (1896). Here occurs a dense rock of
epheline-syenitic composition which closely resembles grennaite. It is
ssociated with nepheline-syenite and a rock which Osann referrs to as
phonolitische Facies des Eläolithsyenits» which approaches the phono-
te occurring as a true effusive rock in the Apache Mts. Concerning the
ode of occurrence of these rocks Osann says (p. 406): ». . .; dieselben
he collected rocks) stellen eine vollständige Uebergangsreihe von
ittelkörnigen Eläolithsyenit durch porphyrische und vollständig pho-
olitartig aussehende Glieder bis zu einem für das blosse Auge gänz-
ch dichten Gestein dar. Bei der Besteigung des 150—200 Meter
ohen kahlen Berges, der die oben beschriebene Aussicht bietet, wur-
en folgende Beobachtungen gemacht: Im allgemeinen bemerkt man
ine nach oben zu abnehmende Korngrösse des Gesteins, die besonders
dem obersten Theil des Berges zu den später zu beschreibenden
honolitischen Grenzfacies des Eläolithsyenits führt. Der vollkommen
ichte Gesteinstypus wurde etwas unter dem Gipfel des Berges auf
em NW-Abhange gesammelt, zugleich wurde an dieser Stelle noch
ne Ueberlagerung durch eine kleine Partie eines mittelkörnigen Kalk-
eines beobachtet.»

The »phonolitische Facies des Eläolithsyenits» and the »vollkommen
ichte Gesteinstypus» (here referred to as »the dense rock») show miner-
ogically good agreement with grennaite. They even contain a zir-
nium silicate of the eudialyte group (p. 417): »Ferner ist das Auftreten
niger seltener Mineralien in der phonolitischen Facies (and in the dense
ck, as appears from a statement on p. 419) zu erwähnen, welche in dem
läolithsyenit nicht beobachtet wurden. Eines derselben, das stellen-
eise recht reichlich vorhanden ist, gehört seinen krystallographischen
nd optischen Eigenschaften nach in die Eudialyt-Eukolit-Gruppe.»

The dense rock resembles grennaite in a striking manner both in
egascopical and in microscopical appearance, as appears from the fol-
wing statements (Osann, pp. 408, 419): »Schliesslich liegen für das blosse
uge vollständig dichte, grüngraue Gesteine vor, welche makroskopisch
nige Aehnlichkeit mit manchen Kalksilicathornfelsen besitzen. Mit

der Lupe kann man sie noch als gemengte Gesteine erkennen, ohne indess einen ihrer Gemengtheile näher bestimmen zu können.», and: »Während die Struktur dieser als ’phonolitische Grenzvarietät des Eläolithsyenits’ bezeichneten Gesteine im wesentlichen bedingt ist durch die Leistenform der Feldspathe, ihre fluidale Anordnung und das eigenthümliche skeletartige Wachstum der dunklen Gemengtheile, zeigt die ganz dichte Grenzvarietät ein davon recht verschiedenes Structurbild. Der Feldspath bildet sehr kleine unregelmässig begrenzte oder zugerundete Körner, die zum Theil trotz ihrer geringen Dimensionen mikroperthitische Verwachsungen noch recht gut erkennen lassen. Von eisenreichen Gemengtheilen finden sich noch reichlich Aegirin, spärlicher Arfvedsonit und Ainigmatit. Die skeletartigen Wachstumsformen dieser Mineralien sind verschwunden, sie bilden rundliche Körner oder kurze Säulchen ohne scharf krystallographische Begrenzung. Verwachsungen von Aegirin und Arfvedsonit sind sehr spärlich, auch hier bildet der erstere die peripherischen, der letztere die centralen Theile. Das dem Eukolit nahe stehende Mineral findet sich noch recht reichlich in kleinen rundlichen Körnern. Auch der Nephelin bildet Körner, seltener kleine Krystalle und zeichnet sich dem trüben Feldspath gegenüber durch seine klare Beschaffenheit aus. Bei der fast durchgehende isodiametralen Form der Gemengtheile ist natürlich auch jede Spur einer fluidalen Anordnung verschwunden, die Struktur ist eine aplitische geworden.»

The example from the Mt. Ord range shows that aplitic facies of nepheline-syenite may be developed under the transition from nepheline-syenite to phonolite, the aplitic rock passing into the one or the other by gradual transitions, and the example from the Cripple Creek volcanic area demonstrates similiar relations. This lends plausibility to the conclusion that grennaite should be looked upon as an intermediate link between nepheline-syenite and phonolite. There is no conclusive evidence of the former extent of grennaite, but it may be that the rock on higher levels, long since eroded away, graded into types of phonolitic texture, and it would not be surprising if at deeper levels we were to find types of nepheline-syenitic texture abundantly developed. Grennaite would then be a hypabyssal rock, representing the connecting link between plutonic and extrusive rock facies. Chilling from the walls can only have played a subordinate role in the development of the aplitic texture of grennaite, the rock showing no variation in grain-size or texture from the margin of the district to its central parts.

As compared with other districts interpreted as sections through volcanic necks, the Norra Kärr district might be considered as representing a relatively more high-seated section than those consisting of hanerocrystalline rocks, but a relatively more deep-seated section than hose consisting of rocks with an effusive texture. The degree of cry- tallinity developed at a certain distance from the surface differs con- iderably from one occurrence to the other, being dependent upon the apidity of cooling, the magnitude of pressure and the composition f the magma. The Katzenbuckel neck shows for example rocks of ffusive character at a surprisingly great depth (estimated at some 600 etres by Salomon (1902, p. 654)), whereas the granular rocks of the ripple Creek volcanic area are considered to have crystallized »within few hundred feet of the surface».

Though in the textural respect it occupies an intermediate position etween nepheline-syenite and phonolite, grennaite must be said, by irtue of its aphanitic character, to come closer to phonolite than to epheline-syenite. From this point of view grennaite might be called a ubphonolite, which term would designate a rock which, if it ad crystallized on the surface, would have formed phonolite and if it ad crystallized under greater pressure would have formed nepheline- yenite.

The pegmatitic development of the schlieren of grennaitic material, ound at some places within the Norra Kärr district, is ascribed to local ccumulations of unescaped volatiles which favoured the formation f larger crystals.

We shall now turn to the phanerocrystalline rocks occurring as in- usions in grennaite. Törnebohm (1906, p. 32) has already stated that ey were older than grennaite. My studies of old as well as new localities n only confirm Törnebohm's statement.

Most alkaline bodies consist of sequences of rocks whose relations to age are not always easily interpreted. In many places, however, eir mode of occurrence seems to indicate that successive intrusions the different rocks have taken place. This is particularly well de- onstrated in Mt. Royal of the Monteregian Hills, which, after the nstruction of a railway tunnel through the mountain, has been agnificently exposed (Adams, 1903 and Bancroft and Howard, 23.) In general the first intrusion occupies the peripheral parts of the ifice and often even the greater part, whereas the later intrusions pear as more or less regularly distributed inclusions. Sometimes a nfocal arrangement can be recognized (Shand, 1921, p. 246).

The Norra Kärr district shows, however, another picture, the inclu- ns being older than the surrounding rock. The mode of occurrence of e phanerocrystalline rocks in grennaite has much in common with e inclusions of canadite in the umptekite of the Almunge district as scribed by Quensel (1914). The Almunge district was interpreted as a deep-seated section through a volcanic neck, and the canadite inclusions were explained as (p. 196) »remains of the older magma, which first filled the channel, but was followed by the intrusion of umptekite, now enveloping some remains of the older rocks as great inclusions». In the case of the Norra Kärr district it is, however, improbable that the inclusions are remains of older rocks which once filled the neck. Their phanerocrystalline texture suggests that they crystallized under conditions quite different from those prevailing during the solidification of grennaite. It is probable that the inclusions crystallized at deeper levels and that they were brought to their present position by the rising grennaite magma.

There is no geological evidence for statements concerning the relative ages of the phanerocrystalline rocks.

2. Petrological Observations.

The consanguinity of the rocks of the Norra Kärr district is demonstrated by chemical, mineralogical and geological evidence. Our problem is to explain the character of this consanguinity and to account for the genesis of the different rocks involved. In view of the hypothetical nature of many of the arguments, the interpretations must, however, be somewhat speculative.

The mineralogical composition of the rocks is rather complicated. Nevertheless it has been shown that three of the phanerocrystalline rocks (viz. the kaxtorpite rocks) have a consistent mineralogical composition distinguishing them from the other two phanerocrystalline rocks, which on the other hand also have certain mineralogical characters in common. The phanerocrystalline rocks thus by nature fall into two mineralogical groups, the kaxtorpite group and the pulaskite-lakarpite group, of which the latter is not so well defined as the former. Grennaite is associated with the pulaskite-lakarpite group through its zirconium content, which distinguishes these rocks from the kaxtorpite group.

The occurrences of pectolite in the kaxtorpite rocks and rosenbuschite in pulaskite and lakarpite are remarkable. As mentioned on p. 235 both minerals are extremely calcium-rich silicates, showing certain structura similarities and essentially differing chemically only in the zirconium content of the rosenbuschite. Both minerals occur in rocks whose chemistry does not indicate that minerals of this composition are to be expected. This circumstance suggests that the formations of the two minerals should be seen in mutual connection. In pulaskite and lakarpite rosenbuschite can be said to take the place of pectolite in the kaxtorpite rocks. The conclusion can hardly be avoided that if it had not been for the zirconium content of the two former rocks, pectolite would have been formed here too, and conversely, if there had been sufficient zirconium available during the formation of the kaxtorpite rocks, rosenbuschite would have been formed.

All evidence points to the fact that the grennaite crystallized out of a magma intruding into the Växiö granite. It has been pointed out that the phanerocrystalline rocks are older than the grennaite and that they probably crystallized at deeper levels. It appears from the description of the chemical relationship that they cannot possibly represent portions of the same magma as grennaite, crystallized under different conditions. A more probable alternative is that they belong to a magmatic differentiation sequence. If this is granted, grennaite must be the final differentiate.

If we considered grennaite to be the final differentiate of a magmatic differentiation sequence represented by the inclusions of phanerocrystalline rocks found in the present level of the Norra Kärr plug, we would have to postulate that these inclusions are fragments of a greater intrusive body into which the plug merges further down.

In our inquiry into the sequence of crystallization of the phanerorystalline rocks, we must resort to the study of their chemical relations. The variation diagrams are not, however, of much help, showing only ittle regular variation. The positions of the different rocks in the variaion diagrams certainly do not express the actual trend of differentiation, xcept possibly within the kaxtorpite group. The zirconium contents of he rocks give, however, certain indications. Zirconium is a typical Restelement» and its enrichment in grennaite together with the other xtreme chemical characters of this rock, as compared with the phanerorystalline rocks, indicate that grennaite is a final differentiate, thus onfirming the geological evidence. The zirconium content of pulaskite nd lakarpite is taken as an indication of closer genetical relationship etween these two rocks and the grennaite than between the kaxtorpite ocks and the grennaite. The kaxtorpite group is considered to be a ifferentiation branch developed earlier than or parallel with the cryslization of pulaskite and lakarpite. It is probable that the differenation sequence contains members in addition to those exposed at the resent level, which undoubtedly would elucidate the nature of the ifferentiation.

Before proceeding to discuss the interrelation of the rocks, we shall udy some features of another occurrence of alkaline rocks, some of hich show great similarity to the Norra Kärr rocks in chemical as well s in mineralogical respects, namely the Oslo region.

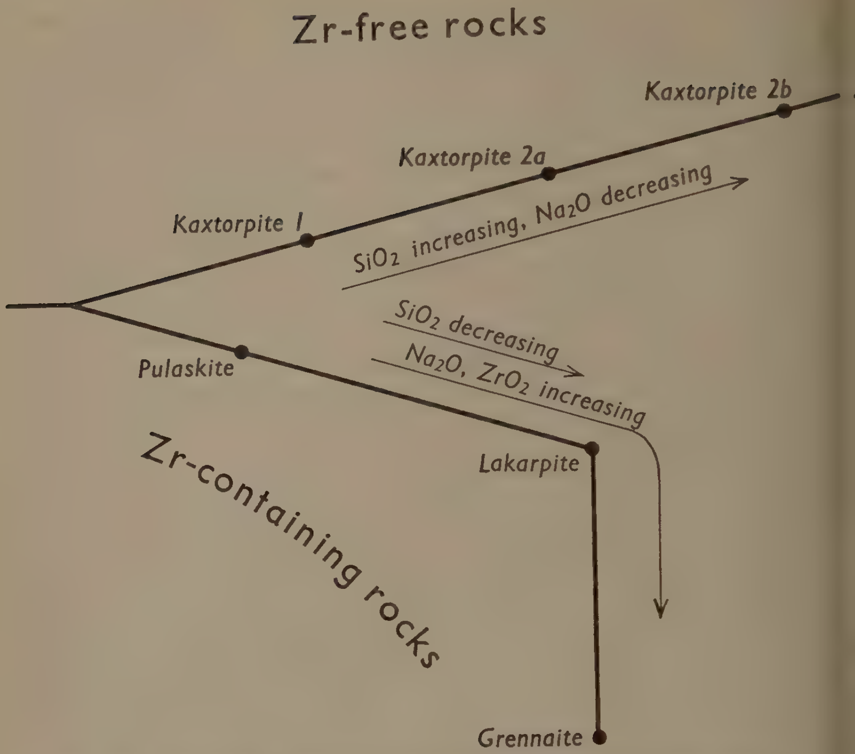

Fig. 32. Diagramatic interrelation of the rocks the Norra Kärr district.

As a primary mineral katapleite is known only in a few localities. The best known occurrence is the nepheline-syenite pegmatites of Langesundsfjord where it occurs in considerable abundance together with eucolite.[1] The pegmatites are for good reason considered to have been derived from lardalite, which rock is a differentiate of larvikite. Lardalite and larvikite are closely connected, which appears from the following statement by Brögger (1898, p. 30): »Auf der anderen Seite steht der Laurdalit dem Laurvikit, mit dem er nicht nur in seinem geologischen Vorkommen verbunden, sondern auch in Struktur und Mineralien-Zusammensetzung (abgesehen von dem grösseren Nephelingehalt) verwandt ist, auch in chemischer Beziehung sehr nahe.» The essential difference is only that lardalite has a smaller content of SiO_2 and a considerably greater content of Na_2O. By the decrease in the amount of SiO_2 as compared with larvikite, lardalite diverges from the general trend of differentiation within the Oslo region (Brögger, 1933, p. 141). This is demonstrated in V. M. Goldschmidt's differentiation scheme of the rocks of the Oslo region (Barth, 1939, p. 90).

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[1] It should be pointed out that we have two kinds of nepheline-syenite pegmatites at Langesundsfjord (Brögger, 1890, pp. 183, 185 and Fersman, 1929, p. 67). Fersman refers to them as »Melinophangänge» and »Katapleitgänge».

Comparing the rocks of the Oslo region with those of the Norra Kärr district, it appears that the pulaskite[1] from Norra Kärr in the chemical respect closely resembles larvikite, and that lakarpite can be said to correspond to lardalite. Pulaskite and lakarpite also show a relationship in texture and mineralogical composition, as was the case with the larvikite and lardalite of the Oslo region. Grennaite obviously corresponds to the katapleite pegmatites of Langesundsfjord, being closely similar in mineralogical composition. No attempt has been made to estimate the chemical compositions of the pegmatites, but to judge from the mineral composition they are probably not very different from that of grennaite. Grennaite might be regarded as an aplitic equivalent of the katapleite pegmatites of Langesundsfjord (cf. the discussion of the geological observations).

The mineral paragenesis of the Norra Kärr district is, however, not one which might be expected in typical magmatic rocks. They probably crystallized under quite peculiar conditions. The abundance of fluorite points to the conclusion that the magma contained a considerable amount of volatiles, an enrichment of which probably occurred during the crystallization. These volatiles are supposed to have had a decisive nfluence upon the mineral paragenesis of the rocks. It is probable that hey already played a considerable role during the crystallization of the phanerocrystalline rocks. Unless this was the case, it is hardly possible hat such minerals as pectolite and rosenbuschite could have been ormed. The magma from which grennaite crystallized is supposed o have been extremely rich in volatiles. The mineral paragenesis of rennaite and particularly of the pegmatitic schlieren in grennaite uggests that this was the case. The occurrence of almost pure microcine individuals together with albite and the presence of natrolite ndicate that the schlieren crystallized from a magmatic solution rather han from a magma.

During the crystallization of the phanerocrystalline rocks an accuulation of volatile constituents is likely to have taken place, finally roducing a residual magma. If this magma had been allowed to crystallize under conditions favourable to pegmatitic crystallization, nepheline-syenite pegmatites would undoubtedly have been formed. If the conclusion in the preceding chapter is correct, however, a passage from the magma chamber was opened up and the residual magma was allowed to ascend. The grennaite then probably crystallized after the greater part of the gas component had vanished. The occurrence of pegmatitic schlieren here and there in the grennaite is considered to be due to the fact that the gas component here was enclosed by the crystallizing grennaite, which prevented its escape.

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[1] It should perhaps be mentioned that the term pulaskite as used by Brögger (1933, 81) in the Oslo region has a somewhat different significance than in this paper. In rögger's conception pulaskite is a rock aproaching nordmarkitic composition whereas this paper pulaskite has been used in the now commonly accepted significance, namely syenite containing a certain amount of nepheline, though not so much that the rock can reckoned as a nepheline-syenite.

In conclusion I shall summarise my views concerning the origin of the Norra Kärr district and the genesis of the rocks:

The existence of an alkaline magma is conceived. After the crystallization of the phanerocrystalline rocks at a deep level, there was an unconsolidated residual magma rich in volatile materials. It is assumed that gases accumulated under a resistant roof until they were given an opportunity to ascend. The rising residual magma carried fragments of the previously crystallized alkaline rocks and in part reacted upon them during its consolidation. The residual magma crystallized as grennaite after the greater part of the gas component had vanished. Thus the phanerocrystalline rocks now exposed as inclusions in grennaite are considered to be the main components of an igneous complex of rocks, and the grennaite which at the present level is quantitatively heavily dominant over them is considered to be the last differentiate which, if it had crystallized under pegmatitic conditions, would have formed nepheline-syenite pegmatites equivalent to the katapleite-pegmatites of the Oslo region.

The above argumentation on the emplacement of grennaite largely coincides with Shand's conception of the emplacement of many alkaline bodies, namely, »that the opening of vents and contraction fissures, at the stage when freezing has proceeded so far that the magma is no longer capable of moving as a whole, may set up a streaming of magmatic gases towards these places of reduced pressure, with the effect of driving the small liquid residue in the same direction and promoting its accumulation in cupolas, pipes and fissures» (Shand, 1922 b, p. XXIX).

I do not venture to discuss the origin and composition of the alkaline magma from which the Norra Kärr rocks are supposed to have crystallized. We shall, however, consider some general problems in connection with the genesis of alkaline rocks.

For a long time it was attempted to explain the origin of all alkaline rocks by one universal hypothesis. The similarity in form and mode of occurrence of many alkaline districts may have contributed to this conception of the problem. The discussion has proceeded, more or less vigorously, ever since Daly (1910) presented his well-known assimilation hypothesis. According to Daly (1933, p. 497) an alkaline magma may be produced from a subalkaline magma (ranging in composition from basaltic to granitic) by reaction with limestone. During this process heavy lime silicates are formed which will sink, carrying silica downwards, thus desilicating the subalkaline magma, while on the other hand alkaline carbonates will rise towards the roof of the magma chamber. In this way an alkaline magma may be separated from the original subalkaline magma. Lindgren (1915, p. 276), Bowen (1915, p. 62) and Smyth (1927, p. 548) inferred that Daly's hypothesis would not explain the enrichment of typical »Restelemente» such as zirconium and lanthanides found in many alkaline rocks. They held that the alkaline rocks were late differentiates of subalkaline magmas.

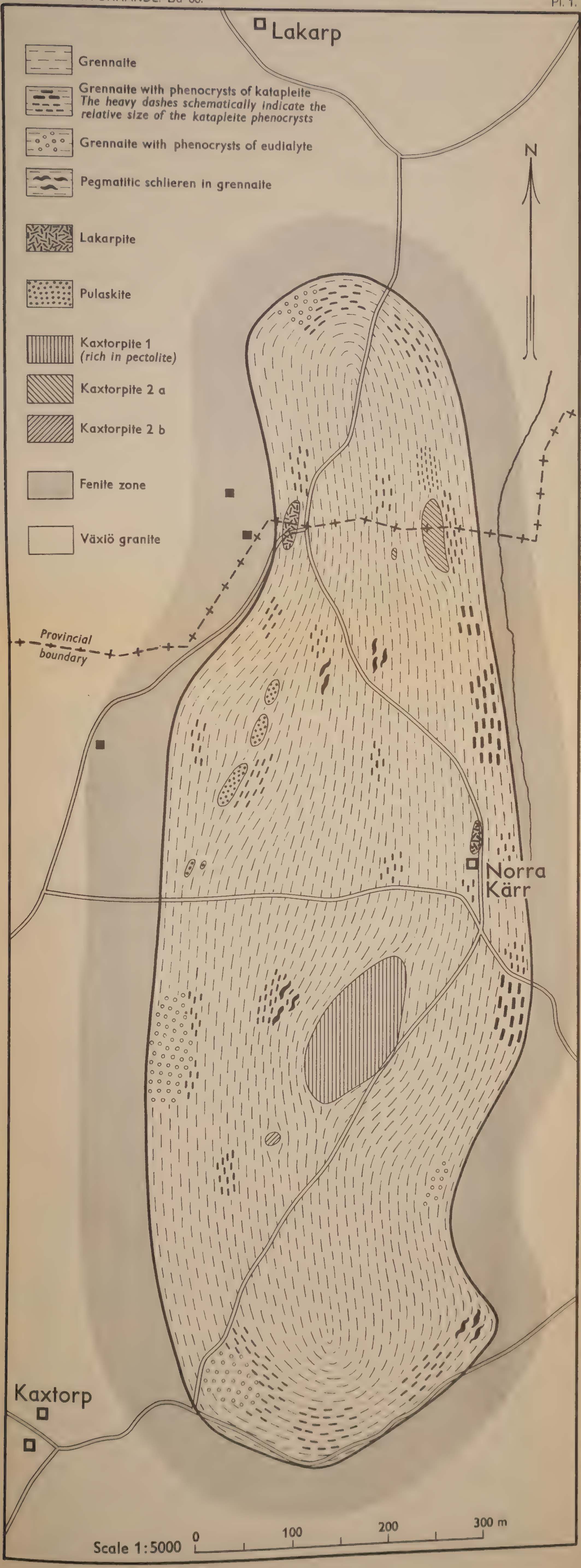
The discussion centred about the question: Did the alkaline rocks owe their origin to assimilation or to differentiation? The geologists divided into two groups; we might call them the »assimilationists» and the »differentiationists», of whom the former adhered more tenaciously to their ideas than the latter. Bowen (1915, p. 64), for example, admitted »that some nephelite rocks, especially melilite-nephelite types, may be formed by the method suggested by Daly». Among the »differentiationists» there was more than one concept of the kind of differentiation leading to the formation of an alkaline magma. Different views are represented by Bowen (1928): late differentiate by the crystallization of a subalkaline magma, Barth (1936): late differentiate by the crystallization of a basaltic magma of alkaline affinity, Smyth (1927) and Lindgren (1933): late differentiate of a subalkaline magma with the aid of the volatile constituents of the magma. The tendency to seek a universal hypothesis for the formation of the alkaline rocks may be illustrated by Shand's attempt (1922 b, p. XXIX) to meet the criticism of the »differentiationists». Shand's hypothesis is a modification of Daly's original one. Instead of conceiving a subalkaline magma assimilating limestone, he conceived an acid residual magma already enriched in »Restelemente», which by assimilation of limestone would produce an alkaline magma.

It is undeniable that from a physicochemical point of view the assimilation hypothesis, as worked out by Daly and Shand, had certain advantages over the differentiation hypotheses. The process leading to the formation of an alkaline magma from a subalkaline magma by reaction with limestone is easily conceivable, whereas the differentiation hypotheses encounter several difficulties of a physicochemical nature. It is not conceivable how an alkaline residual magma can come into existence by simple fractional crystallization of a subalkaline magma

(Barth, 1939, p. 89). Neither is a derivation from a basaltic magma of alkaline affinity (Barth, 1936, p. 349) able to give a satisfactory explanation. The basaltic differentiation may explain the development of rocks of moderate alkalinity, which process is exemplified by the soda-trachytes and the sodium-poor phonolites of the oceanic islands (Barth, 1931, p. 528), but it fails to explain the development of extremely sodium-rich rocks. Smyth (1927) and Lindgren (1933) improved the hypothesis of the differentiation from a subalkaline magma, reckoning with an extended effect of the volatile constituents of the magma. »It is held . . . that the alkaline rocks are late products of differentiation; and that they are formed with the aid of the volatile constituents of the magma, these being not only mobile themselves but having also the capacity to form mobile compounds with many elements.» (Lindgren, 1933, p. 163.)

On account of the fact that there was no outcrop of carbonate rocks in the neighbourhood of many alkaline districts, the assimilation hypothesis was abandoned by one author after the other. On the other hand, at certain places evidence accumulated in favour of the assimilation hypothesis. Eventually more and more petrologists arrived at the conclusion that the problem of the origin of the alkaline rocks had been excessively simplified and that no universal hypothesis for their genesis was tenable. Wegman's interpretation (1938, p. 79) of the alkaline rocks of Julianehaab as owing their existence to metasomatic agents, promoted the common opinion that alkaline rocks might be formed in more than one way, or as expressed in Barth's words: »Es ist anzunehmen, dass die meisten Alkaligesteine eine recht komplizierte Bildungsgeschichte aufweisen und dass infolgedessen keine einzige der erwähnten Hypothesen in der Lage ist, ihre Entstehungsweise restlos zu erklären. Die Alkaligesteine sind sicherlich »polyphyl» (um einen Ausdruck aus der Paläontologie zu entlehnen): Sie können von mehreren Seiten stammen. Darüber sind sich wohl jetzt alle Petrographen einig» (Barth, 1939, p. 88).

Wegman's highly interesting interpretation of the alkaline rocks of the Julianehaab complex has given a new aspect to the genesis of the alkaline rocks (1938, p. 79): »The new working hypothesis may be defined as follows: The Gardar Formation was intruded by a series of abyssal rocks and syntectic rocks embracing the series essexite—arfvedsonite-granite. A very large part of the edifice, the intrusive rocks as well as the wall rocks, were subsequently transformed through imbibition of solutions, thus turning into alkaline rocks.» Wegman (p. 77) regards the lujavrite to be »a metamorphic correlate to the porphyry formation» and the naujaite to be a correlate to the essexite gabbroes. He assumes the solutions added to the porphyry formation and essexite


Lakarp
Grennaite
Grennaite with phenocrysts of katapleite
The heavy dashes schematically indicate the relative size of the katapleite phenocrysts
Grennaite with phenocrysts of eudialyte
Pegmatitic schlieren in grennaite
Lakarpite
Pulaskite
Kaxtorpite 1 (rich in pectolite)
Kaxtorpite 2 a
Kaxtorpite 2 b
Fenite zone
Växiö granite
N
Provincial boundary
Norra Kärr
Kaxtorp
Scale 1:5000
0
100
200
300 m

GEOLOGICAL MAP OF

THE NORRA KÄRR DISTRICT

BY

O. J. ADAMSON

A.-B. KARTOGRAFISKA INSTITUTET
ESSELTE AB STOCKHOLM 1944

gabbroes yielding lujavrite and naujaite, to be »the last remnants of the essexite series».

Wegman's point of view is certainly worth consideration, and it is possible that it is also applicable to other occurrences of alkaline rocks than the Julianehaab district. In the case of the Norra Kärr district t must, however, be rejected, the field evidence hardly being reconcilable with a metasomatic origin of the rocks, even if the paragenesis of some of them might invite speculations along this line.

Since the country around the Norra Kärr district is composed entirely of acid rocks, I do not consider it necessary to discuss the origin of the alkaline rocks there as possibly being due to contamination of limestones. I regard the differentiation hypothesis far more probable, especially in the form worked out by Smyth (1927) and Lindgren (1933).

Finally I should like to draw attention to the remarkable fact that the presence of zirconium minerals in a number of alkaline rocks seems to exclude carbonate minerals. It cannot be a mere coincidence that the carbonate-rich alkaline districts of Fennoscandia, e.g. Fen, Alnö[1], Särna and Turja show no zirconium minerals, whereas the zirconium-accentuated alkaline districts, Umptek, Lujavr Urt and Norra Kärr are completely devoid of carbonate minerals. I tend to the opinion that there is some fundamental difference in the genesis of the carbonate-rich alkaline rocks and the zirconium-rich alkaline rocks. I do not imply that each type should necessarily be ascribed to a certain genetical origin. Similar rocks may originate in more than one way, exemplified by the Julianehaab rocks which Wegman explained by metasomatosis, and rocks of other zirconium-rich districts best explained by magmatic differentiation. I think, nevertheless, that it is justified to look upon the zirconium-rich alkaline districts as having certain genetical features in common, distinguishing them from the carbonate-rich alkaline districts and from districts showing neither of these chemical characters.

VIII. Age of the Norra Kärr District.

The geological relations of the Norra Kärr district show that it is ounger than the Växiö granite and also younger than the regional deormation of this rock. This is the only statement relating to the age of he Norra Kärr district for which we have conclusive evidence. The vidence is: structural conformity of the grennaite with the boundary f the district and fenitization of the surrounding granite.

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[1] A description of baddeleyite from Alnö by Hussak (1898) has been shown to be due a mistake, probably a confusion with melanite (von Eckermann, 1939, p. 413).

It is not likely that more geological evidence can be produced which would contribute to the decision of the age of the Norra Kärr district. In the case of the Alnö district, for example, the question of the age has been partially answered by the fact that Alnö dykes have been observed cutting Jotnian formations. No dykes have, however, been observed emanating from the Norra Kärr district. Otherwise there might have been a chance that such a dyke would occur in contact with the Visingsö formation, the nearest outcrop of which is situated only about one kilometre from the Norra Kärr district.

In the course of time speculations have arisen concerning the age of the Norra Kärr district, based upon tectonical conditions. Törnebohm (1906, p. 33) assumed that the deformation of the Växiö granite in the area east of Vättern owed its origin to the formation of the Vättern depression and the accompanying down-faulting of the Visingsö formation; the deformation would consequently be younger than the Visingsö formation, which for petrographical reasons Törnebohm parallelled with the Keuper formation in Skåne. With a reservation for possible incorrectness of the assumptions in his argument, Törnebohm concluded that the Norra Kärr district »ej kunna vara äldre än början af juratiden men möjligen yngre».[1]

As to the age of the Visingsö formation, it has now been shown to belong to Lower Cambrian or upper pre-Cambrian (Brotzen, 1941, p. 245). Törnebohm's speculations as to the age of the Norra Kärr district must therefore be reconsidered.

Gavelin (1912 b) opposed Törnebohm's view regarding the connection of the Växiö granite and the formation of the Vättern depression, and held that »den kataklastiska förskiffringen vid Vättern är af vida äldre datum än Visingsöseriens nedsänkning och Vätterbäckenets uppkomst»[2] (p. 33). Gavelin arrived at the conclusion that the deformation of the Växiö granite took place in »pre-Cambrian time».[3] Not being aware of the precrystalline character of the schistosity of grennaite (katapleiit-syenit) he thought that the schistosity had been developed simultaneously with the deformation of the granite and therefore also regarded the Norra Kärr district as of »pre-Cambrian age» (p. 36). However, considering the precrystalline character of the schistosity of grennaite, Gavelin's reasons for ascribing a »pre-Cambrian age» to the Norra Kärr district will not hold good.

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[1] In translation: »could not be older than the beginning of the Jurassic period but possibly younger».

[2] In translation: »the cataclastic deformation near Vättern is of much older date than the down-faulting of the Visingsö series and the formation of the Vättern depression».

[3] The Växiö granite is now classified as belonging to the Gothic epoch of the Fennoscandian pre-Cambrian (Magnusson, 1936).

It is, of course, possible that the intrusion of grennaite took place at the final stage of the deformation of the Växiö granite and that it solidified somewhat after the deformation processes had come to an end, but it seems more probable that the grennaite is definitely younger than the deformation of the Växiö granite.

In conclusion it may be pointed out that after the finding of a radioactive mineral in the pulaskite of the Norra Kärr district, it is at least theoreticallly possible that the question of the age of the district can be settled in a satisfactory manner.

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Literature.

ABBREVIATIONS:

N. G. T. = Norsk Geologisk Tidsskrift.
N. J. = Neues Jahrbuch für Mineralogie etc.
S. G. U. = Sveriges Geologiska Undersökning.
T. M. P. M. = Tschermak's mineralogische und petrographische Mitteilungen.
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By

G. Erdtman.

(MS. received Nov. 19, 1943.)

This eighth issue of »Literature on Pollen-Statistics» contains papers published in the years 1940—1942, a few also in 1943 (in conformity with some of the previous issues it also contains a number of older, chiefly botanical papers). The list can hardly be complete since the compiler has included chiefly papers sent to him personally. But as a result of the war the international exchange of scientific literature has been essentially reduced.

The publication of this issue can only be continued in case papers on pollen-statistics and similar topics regularly come into the hands of the editor.

Abbreviations:

A: Alnus; Ab: Abies; B: Betula; C: Carpinus; Co: Corylus; F: Fagus; P: Pinus; Pc: Picea; Q: Quercus; S: Salix: T: Tilia; U: Ulmus.

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I. Introduction.
II. Chemistry of peat (by Dr H. Erdtman).
III. Pollen preparations.
IV. Preparation of fossil pollen-bearing material.
V. Pollen and spore morphology (terminology; pollen diagnoses).
VI. Pollen morphology (Monocotyledons).
VII, VIII. Pollen morphology (Dicotyledons).
IX. Pollen morphology (Gymnosperms).
X. Spore morphology (Pteridophyta and Bryophyta).
XI. Pollen Analyses and their graphical representation.
XII. Correlations.
XIII. Output and dissemination of pollen.
XIV. Surface samples.
XV. Pollen flora of peat samples.
XVI. Geographical survey.
XVII. Tertiary deposits.
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esse sulphur, sed pulverem vegetabilem, de Pino et Abiete vel Corylo, vel et de Musco terrestri clavato, aliisque plantis, in aërem, vento elevatum, deinde cum pluvia deciduum»).

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Diabasintrusioner och algonkisk tektonik i Medelpad.

En profil genom Torpshammartunneln.[1]

Av

SVEN HJELMQVIST.

Vid det stora kraftverksbygge, som Statens Vattenfallsverk utfört d Gimån i Medelpad, har en nära fem km lång avloppstunnel blivit sprängd i berg från södra ändan av Nordanedesjön till Gimåns ut-pp i Ljungan vid Torpshammar. Det snitt genom berggrunden, som nna tunnel blottat, har bl. a. å ena sidan givit möjlighet att studera vindiabasens intrusionssätt i detta område, å andra sidan har det vit en inblick i de betydande rörelser i jordskorpan, som synbar-en ägt rum i nära samband med diabasens framträngande.

Den rådande bergarten i trakten är en grå gnejsgranit, vilken van-en är rätt inhomogen och övergår i sliriga ådergnejser, i vilka man n iakttaga rester av grå, småkornig gnejs av sedimenttyp. De vita rorna i ådergnejsen svälla stundom ut till betydande pegmatitkört-. Därjämte uppträder en vit eller ljusgrå, delvis något fläckig granit, ken tydligen hör nära samman med pegmatiten. Den är vanligen edelkornig och innehåller relativt rikligt med ljusröd granat. De mörka ckarna bestå bl. a. av glimmer och sillimanit. Graniten torde till-ra Härnögranitgruppen.

De olivindiabaser, som genomsätta den äldre berggrunden, äro till n ålder antingen jotniska eller postjotniska, prekambriska. Då inom r ifrågavarande område jotniska sedimentbergarter saknas, till vilka abaserna skulle kunna sättas i förhållande, är det lämpligare att i tta fallet helt allmänt använda benämningen algonkisk.

På Lundbohms karta över berggrunden i Västernorrlands län[2] ha givits flera massivliknande förekomster av olivindiabas i Medel-d. I beskrivningen säger Lundbohm, att olivindiabasen uppträder som »rätt stora massiv, små kupper eller gångar».[3] Längre fram till-gar han dock beträffande förekomsterna i västra Medelpad, att det ännu återstår att utröna, huruvida de verkligen »bilda isolerade kupper, eller om en del af dem måhända tillhöra större gångar af diabas».

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[1] Föreliggande uppsats är grundad på iakttagelser, som giorts i samband med en edning av de geologiska förhållandena omkring Gimån för Kungl. Vattenfallssty-ens räkning. Förf. ber att få uttala ett vördsamt tack till Vattenfallsstyrelsen, n bekostat tryckningen av uppsatsen.

[2] Lundbohm, Hj., Berggrunden inom Vesternorrlands län. S. G. U. Ser. C. Nr 177. 1899.

[3] A. a. sid. 13.

Torpshammartunneln skär på sin väg ett flertal diabaser av växlande mäktighet och uppträdande. Bland dessa dominerar fullständig en flack och samtidigt mycket betydande diabaskropp i mellersta dele av tunneln. Den stryker i västnordväst—ostsydostlig eller nordväst—sydostlig riktning och är blottad på en sträcka av 600 m i tunneln Dess stupning är c:a 10°—15° mot SV. Mäktigheten beräknas till öve 100 m. Ungefär parallellt med denna men skild från den av en någr tiotal m mäktig skiva av gnejsgranit löper en annan betydande gån med samma flacka sydvästliga sidostupning. Dess mäktighet uppgå till omkring 30 m. Dessa båda äro de enda diabasförekomster, som blivit utmärkta på profilen fig. 1. De utgöra fortsättningen mot NV av den »diabasplugg», som förekommer på Lundbohms karta i trakte av Bosjön och som alltså sträcker sig minst 5 km längre åt detta håll än vad nämnda karta visar. Sammanhanget framgår av flera blottningar i dagen. Huruvida den även kan tänkas vara förbunden med de diabasförekomster, som på Lundbohms karta angivas ett par mil längre mot NV, kan ej avgöras med föreliggande observationsmaterial. E bestämd slutsats kan man emellertid draga av det sagda, och det ä att åtminstone denna »diabasplugg» i verkligheten är en flack gång av mycket betydande dimensioner. Studerar man Lundbohms karta över berggrunden i Västernorrlands län närmare, skall man f. ö. finna att de här angivna diabasförekomsterna i Medelpad i huvudsak äro belägna inom ett jämförelsevis smalt västnordväst—ostsydostligt bälte som sträcker sig från kusten vid Galtströms bruk till Jämtlandsgränse N och NV om Ånge.

I sitt nedre lopp skär tunneln ytterligare ett antal diabaser, såvä flacka lager som brantare gångar. På ett ställe har en kontakt observerats mellan en flack diabas och en brantstående gång. Den senare ä yngre och visar en tydlig avkylningskontakt mot den förra. Petrografiskt föreligger icke någon nämnvärd olikhet mellan de båda förekomsterna, och skillnaden i åldershänseende behöver ej heller vara stor. De kunna mycket väl tillhöra samma intrusionsepok. Såvä den nämnda som övriga branta diabasgångar, som skäras av tunneln synas i huvudsak ha en västnordväst—ostsydostlig strykningsriktning

I petrografiskt avseende uppvisa de olika diabasförekomsterna endas ringa variationer. Samtliga undersökta fall äro olivindiabaser, stundom med olivinen omvandlad till serpentin eller klorit. Övriga ingåend mineral äro plagioklas (basisk labrador), ljust rödbrun titanaugit sam titanomagnetit, i smärre mängder därjämte biotit och apatit. Strukturen är ofitisk till subofitisk. Olivinen bildar vanligen mer elle

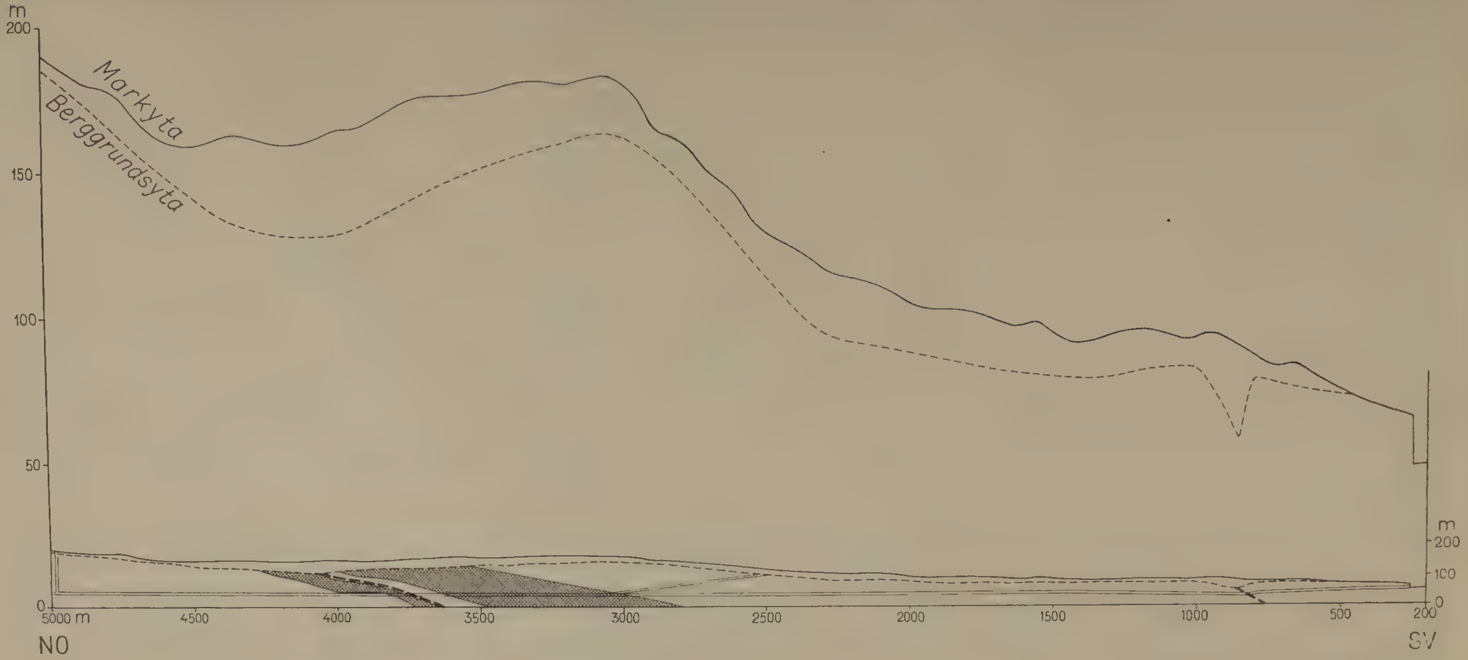

Fig. 1. Profil av tunneln vid Torpshammar. Rutbeteckning = diabas. Grov streckad linje = brecciezon. I undre delen av bilden äro höjd- och längdskala lika. I övre delen är höjdskalan tio gånger större än längdskalan.

mindre idiomorfa korn. Kornstorleken växlar från finkornig, nästan tät till jämförelsevis grovkornig med halvcentimeterlånga plagioklaslister. I en borrkärna har iakttagits en monzonitisk utbildningsform av diabasen. Den består av alkalifältspat, andesin, hornblände, augit och kvarts, vartill komma ilmenit, apatit och biotit. Augiten ligger delvis som rester i hornbländet. Alkalifältspaten uppträder övervägande i form av självständiga korn men ingår även i skriftgranitiska sammanväxningar med kvarts. Hornbländet bildar långa, prismatiska kristaller av en halv cm:s längd. Även ilmeniten förekommer i form av smala stänglar, vilka mäta 2—6 mm i längd. Liknande monzonitiska utbildningsformer av olivindiabas ha förut beskrivits av H. von Eckermann.[1]

Vid gränsen mellan gnejsgraniten och det undre flacka diabaslagret (se fig. 1) förekommer en mycket betydande brecciezon, vilken synes förlöpa tämligen parallellt med diabasen här, d. v. s. har en stupning av omkring 20°—30° mot SV. Det uppspruckna partiet börjar i gnejsgraniten, som delvis är fullständigt söndersmulad, och sträcker sig långt in i diabasen. Denna är genomdragen av serpentinklädda släppor, efter vilka den faller sönder i större och mindre block. Bl. a. märkas kraftiga sprickor ungefär vinkelrätt mot gnejsgranitkontakten. I mineralogiskt avseende är diabasen förändrad såtillvida, att all olivin försvunnit och ersatts av serpentin och klorit, som även genomdraga bergarten i form av ådror. Även en riklig nybildning av prehnit har ägt rum, framför allt i gnejsgraniten. I strukturellt avseende är diabasens omvandling mindre framträdande. Det förefaller, som om de huvudsakliga rörelserna utlösts väsentligen i gnejsgraniten eller i själva kontaktzonen mellan gnejsgranit och diabas. Dock träffas även i diabasen smala skölzoner, efter vilka glidningar ägt rum. Att verkligen betydande rörelser skett, visar bergets sönderbrutna beskaffenhet.

Vad tiden för dessa rörelser beträffar, förefaller det ganska klart, att de måste ha försiggått i nära samband med diabasens framträngande. Å ena sidan har diabasen själv träffats av sönderbrytningen, vilket visar, att rörelserna fortgått även efter diabasens intrusion, i varje fall efter det undre diabaslagrets bildning. Å andra sidan har en uppkrossning av gnejsgraniten börjat redan innan diabasmagman trängde fram, vilket framgår därav att i närheten av diabaskontakten smala krosszoner i gnejsgraniten intruderats av diabas, som hopläkt sönderbrutna partier och nu innehåller små rundade brottstycken av gnejsgranit. Även parallellismen mellan diabasen och brecciezonen tyder på ett samband dem emellan. Följaktligen får man antaga som mycket sannolikt,

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[1] Eckermann, H. von, The Loos-Hamra region. G. F. F. Bd 58. 1936. id. 315.

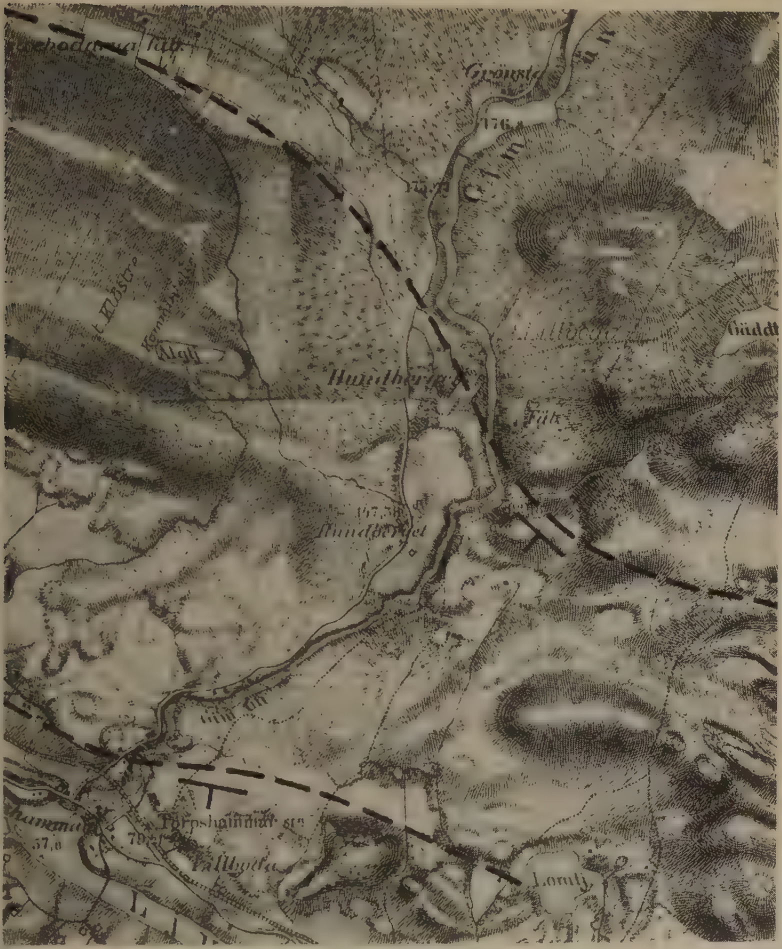

Fig. 2. De i Torpshammartunneln påträffade brecciezonernas läge i terrängen. Skala 1 : 50 000.

att brecciebildningen, liksom diabasen, är av algonkisk ålder. På grund av förskjutningszonens flacka läge har förmodligen rörelsen haft karaktären av uppskjutning, varvid det södra bergartsblocket skjutits upp över det norra.

I södra delen av tunneln förekommer en liknande brecciezon, vilken dock här ej åtföljes av diabas. Dess riktning och stupning visar emellertid så stora likheter med den ovan beskrivna rörelsezonen, att det är mycket troligt, att dessa båda höra nära samman. Brecciezonen i tunnelns syddel har en västnordvästlig—ostsydostlig strykning och stupar 20°—30° mot SSV. Det starkt sönderkrossade berget har en bredd av 1,5—3 m men delar upp sig i smalare zoner med fastare berg emellan. Här ses även lerskölar, i vilka smärre stenar ligga inbäddade i en lerig mellanmassa på ett sätt, som ganska mycket erinrar om vanlig morän. Berget är på båda sidor om den egentliga brecciezonen, till ett dju av åtskilliga meter, ganska starkt söndersprucket. Även denna zon betecknar uppenbarligen en kraftig förskjutning i berggrunden, och lik som i förra fallet torde det även här vara fråga om en uppskjutning varvid det sydliga blocket pressats upp över det nordliga. Av intress är att konstatera båda de studerade brecciezonernas flacka läge. I d allra flesta fall är det ej möjligt att avgöra stupningen av de brottlinjer som göra sig gällande i den nuvarande topografien. Det är i allmänhe först genom ett studium av de tektoniska förhållandena i tunnlar oc gruvor, som detta blir möjligt. I själva verket torde flacka eller jämförelsevis flackt stupande brottzoner vara en relativt vanlig företeels i vårt lands berggrund.

Båda de skildrade brecciezonerna i Torpshammartunneln motsvara ovanför denna av tydliga svackor i berggrunden, såsom profilen fig 1 visar. Mest framträdande är detta förhållande vid brottzonen i södr tunneldelen. I någon mån kan detta bero på att flera borrningar blivit utförda här, vilket möjliggjort en mera detaljerad bild av berggrundsytan. Jordtäcket är också mindre härstädes. Men även vid de norra brecciezonen framträder tydligt en svacka i berggrundsyta ehuru dold av ett mäktigt jordtäcke.

Utanför tunnelområdet kan man följa de nämnda brottlinjerna terrängen, där de delvis bilda tydliga sänkor. Som kartan fig. 2 visa representeras den norra linjen av sänkan vid Klöstrebodarna fäb. o sträcker sig därifrån mot SO i riktning mot Bosjön. I diabasen V o Bosjön märkes en upprepning av samma brottlinjesystem, varvid terrängen blivit uppdelad i flera parallella, nordväst—sydostligt strykand ryggar. Den södra brottlinjen gör sig morfologiskt gällande i den sänk som framgår N om höjden vid Lillboda, mellan Lomtjärn i öster o Gimåns nedre lopp i V.

Över huvud taget utgöra nordväst—sydostliga eller västnordväst—ostsydostliga linjer ett ganska framträdande element i Medelpads topografi. Både bergsträckningar och dalgångar med till dem hörande å- och sjösystem äro i rätt stor utsträckning orienterade i denna riktnin Även Ljungans dalgång kan inordnas i samma system. Det förefalle ganska sannolikt, att anläggningen av detta drag i morfologien står samband med framträngandet av de algonkiska diabaserna och de rörelser i jordskorpan, som voro förbundna därmed.

Tryckt med bidrag från K. Vattenfallsstyrelsen.

Some Notes on the Reaction Series.

By

HARRY VON ECKERMANN.

The well known reaction series of crystallization of magmas, originally conceived by Bowen, consist of one discontinuous dark-mineral series and one or two continuous light-mineral series which converge towards a common pegmatitic and hydrothermal series.

The discontinuity is associated with the formation of minerals of different atomic structures, the continuity with isomorphic replacements, viz. solid solutions, mainly substitutional. Within the discontinuous series certain parts may be continuous.

The discontinuous series are characterized by the increasing complicacy of the SiO_4-tetrahedralinkages at decreasing temperature, the sequence reading:
»isolated tetrahedra—single chains—double chains—sheets», or expressed in terms of polymerization

$$(SiO_4)^{4-} — (SiO_3)^{2-} — (Si_4O_{11})^{6-} — (SiO_2).$$

This sequence is synonymous with an increasing volume of the unit cell, exemplified by the following table:

Forsterite	294.2 Å^3
Fayalite	313.1 »
Diopside	433.6 »
Bronzite	838.0 »
Hyperstene	838.5 »
Hornblende	924.5 »
Biotite	978.7 »

The former part of the series, ending with the pyroxenes, has recently been briefly discussed by F. E. Wickman from kinetic viewpoints, based on the activation energy of migration of the ion, the E-value (4). His illuminative representation clearly indicates the decisive influence of the E-values on the mineral sequence.

The latter part of the series is characterized by an increasing percentage of hydroxyl and fluorine entering the structure contemporaneously with an increasing concentration of volatiles in the magmatic solution.

During magmatic conditions Al combines with oxygen in four- or six-coordination. When Al, thanks to its similar ion-radii, replaces Si in a silicate-anion, a four-coordination is favored against a six-coordination when surrounded by OH. Consequently, as emphasized by Niggli (3), the content of volatiles in the magma has an essential influence on the coordinative behaviour of the Al, and may be taken as mainly responsible for the accompanying structural changes from single SiO_4-tetrahadra-chains into double chains and sheets. The strongly polarizing influence of the volatiles alters the dominating influence of temperature on the E-values, as already perceived by Wickman, and makes the application of the latter extremely complicated.

The atomic ratio Si:Al of the first crystallized dark minerals is infinite but decreases gradually to a limit of 3.0 in the last mineral of the series, the biotite. While the discontinuous series generally indicates an increasing silification towards lower temperatures of formation, its sequence is by no means an unbroken curve, as the replacement of Si by Al will counteract it up to a point, set by the limits of isomorphic exchange.

The degree of this structural replacement, regulated by the coordinative influence of the volatiles, may vary considerably in similar minerals from equal rocks and even within a practically homogeneous rock-body. No statistical survey of such replacements has yet been undertaken, but a series of mineral analyses executed in connection with a still unpublished work of the present author seems to indicate a decrease of $Al \rightarrow Si$ replacement in augites and biotites simultaneous with an increase of sodium, potassium, and calcium ions, viz. ions of high coordination number.

As the content of calcium decreases and that of alkalies, mainly sodium, increases in the minerals of the reaction series (olivine ex-cluded), a very small replacement $Al \rightarrow Si$ is suggested to take place at the beginning and end of the series, the maximum occurring at an intermediate point of the series.

A feature of the series, too, is the gradual increase of the (Na, K): Al atomic ration from 0.0 in the olivines to a maximum of 1.0 in the biotite. Another noticable characteristic is the increasing oxidation-ratio $Fe^{3+}:Fe^{2+}$. As pointed out by Wickman the latter is mainly due to a decrease of the Fe^{2+}-content during differentiation, — the losses of Fe^{3+} being counteracted by successive oxidation of Fe^{2+}. This oxidation does not require any great amounts of oxygen in the melt, as the partial pressure of O_2, necessary for the hematite-magnetite stability below 1 300 C°, is very low. The comparatively stable content of Fe^{3+} of the minerals may be responsible for the non-observation in the case of the above mentioned series of analyses of any definite relationship between oxidation-ratio and Al → Si replacement.

Finally, for completeness, the well known fact of divalent iron being enriched in the series in comparison to magnesium may be mentioned. To Wickman's conclusion that in a non-oxidizing environment the residual liquids would be iron-rich, however, a word of caution may be added, as in nature such liquids do seem to occur, too, under less restricted conditions. For instance, the noritic gabbro at Nordingrå (2) must have contained a fair amount of oxidizing volatiles, but, nevertheless, its lastly crystallized interstitial liquid has mainly been a titanieferous magnetite.

The continuous series are characterized by their three-dimensional framework of linked SiO_4 and AlO_4 tetrahedra throughout. They are of two kinds: the normally occurring plagioclase-series and the exceptional alkalifelspar-series, proposed by Barth. In the following the first mentioned only will be discussed.

The continuous transition from bytownite to albite is, according to Wickman, due to different E-values, viz. different mobility of the calcium and sodium ions, especially at high temperatures. In this series, too, there is a considerable change of the volume of the unit cell, consisting of a decrease of about 55 %.

The at present available, scanty and unsatisfactory, structural data indicate the following volumes: labradorite 1 335.1 Å³, albite 601.2—622.0 Å³, orthoclase 725.5 Å³ and sanidine 697.5 Å³.

Although the system anorthite-albite is generally considered a perfect example of isomorphous series, the X-ray data do not verify a corresponding gradual change of the size of the unit cell, but indicate a sudden jump in size at an intermediate point, suggesting two converging solid solution series, anorthite, respectively albite being the solvents.

It may be noted that the potassiumfelspar generally seems to begin crystallizing at a point where its unit cell volume approximately corresponds to that of the simultaneously crystallizing plagioclase. There s a marked difference, too, in the cell-sizes of orthoclase and albite, which may be ascribed to the same reason as the distorsion of the structure (cfr Bragg, 1), viz. the smaller size of the Na ions allowing the tetrahedra to close in somewhat around the cavity in which the ions are placed. Both these remarks are of importance to the problem of perthitization.

Pure anorthite does not form in primary magmas, the closest approach being the plagioclases of some olivine-bearing gabbroes and the basic lavas of Miyaka, but we may, nevertheless, regard this mineral as the initial member of the reaction series, Consequently, the two end members

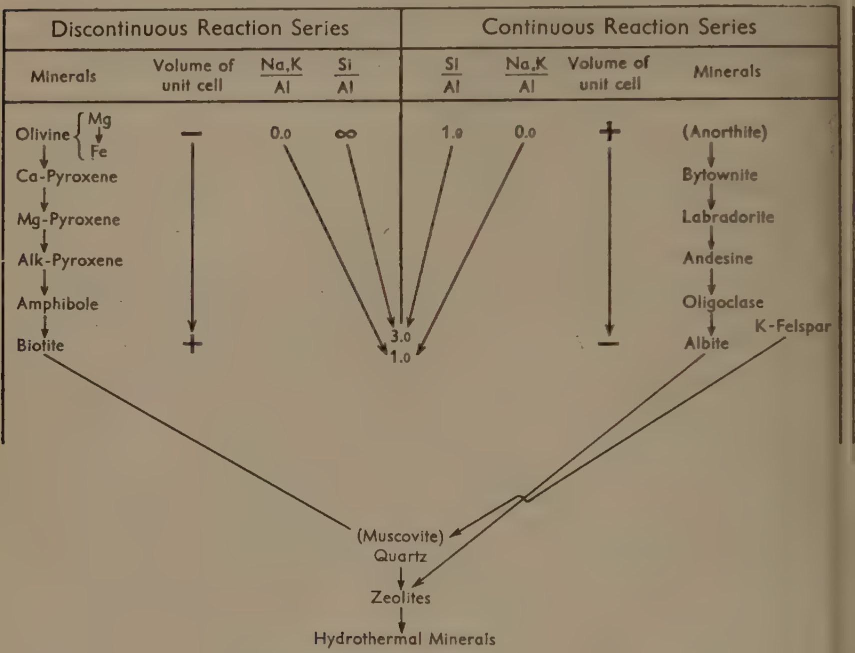

Fig. 1.

can be written Ca[Al$_2$Si$_2$O$_8$] and Na[AlSi$_3$O$_8$], indicating a structural replacement of 50 % of the silicon by aluminium in the tetrahedra-frame of the anorthite against 25 % in the case of the albite. The atomic Si : Al-ratio, therefore, increases from 1.0 to 3.0.

The (Na, K) : Al ratio, on the other hand, increases from 1.0 to 3.0.

The discontinuous and continuous reaction series, when plotted together in a diagram, fig 1, emphasize an interesting feature: the converging of the respective (Na. K) : Al and Si : Al ratios towards the same final values: 1.0, respectively 3.0.

This strongly suggests that up to the end of the two series, the mutual relations of alkali-aluminium-silicon ions has been one of the governing factors regulating the mineral sequence, notwithstanding the increase of volatiles. It may be observed, however, that the identical structural positions occupied by Al and Si in albite (orthoclase) has no correspondence in biotite, where there is no similar structural replacement Al → Si. It seems, therefore, probable, that an application of Wickman's conception of the E-values to the end members of the discontinuous series, too, should not be unfeasible.

The serious complications begin at still lower temperature, where the concentration of the volatiles becomes excessive and the above stressed regularity ceases. In muscovite, for instance, the (K, Na) : Al ratio drops to 1.5 and the Si : Al ratio to 0.33. In analcite and natrolite the Na : Al ratio is maintained at 1.0 but the Si : Al ratio drops to 2.0, respectively 1.5.

Ergo, we may say that the (Na, K) : Al and Si : Al ratios of 1.0, respectively 3.0, define the low-temperature limit of liquid-magmatic crystallization of primary basaltic magmas, beyond which limit follow the pegmatitic—pneumatolytic—hydrothermal stages.

References:

1. Bragg, W. L., Atomic structure of minerals, Cornell Univ. Press, 1937.
2. v. Eckermann, H., The Anorthosite and Kenningite of the Nordingrå-Rödö region, G. F. F. 1938.
3. Niggli, P., Das Magma, Leipzig 1937.
4. Wickman, Frans E., Some aspects of the geochemistry of igneous rocks and of differentiation by crystallization, G. F. F. 1943.

Orogene Erscheinungen im südwestlichen Schweden.

Von

NILS SUNDIUS.

Im südwestlichen Teil von Schweden gibt es mehrere Erscheinungen die auf orogene Bewegungen hindeuten, die aber bisher in Zusammenhang nicht diskutiert worden sind und grösstenteils hinsichtlich der zeitlichen Datierung unsicher sind. Hieher gehören vorerst die dislozierten Sedimentformationen in Dalsland und bei Almesåkra in Småland dazu sind aber auch gewisse durchgehende Verschiebungs- und Mylonitisierungszonen zu rechnen, die teilweise den grösseren Teil des Landes in N—S-Richtung durchqueren. Eine von diesen ist die Dislokationslinie, die von der Gegend des Sees Mjörn bei Alingsås der Kållandsö und dem Värmlandsnäs entlang bis Kil bekannt ist. Wir wollen sie im Folgenden die *Kållandsö-Linie* oder *-Verschiebung* nennen. Sie tritt in der Topographie durch die höhere Lage der Gesteinsoberfläche westlich der Linie hervor. Bei den Frykenseen teilt sie sich nach Magnusson[1] in zwei Äste, die ein mylonitisiertes und gegen Norden sich erweiterndes Gebiet umfassen und bis an die Gegend des Sees Mjösa in Norwegen verfolgt werden können, wo sie wie die Mylonite von Kambrosilur und Sparagmit überdeckt werden. Wir nennen nach Magnusson diese Mylonitzone die *zentralvärmländische Mylonitzone.*

Durch die Beschreibungen der kombinierten Erdlager- und Gesteinskarten gut bekannt ist der nördliche Teil der Kållandsö-Verschiebung bis in die Gegend von Lidköping. 1919 hat Sandegren die Strecke dem Värmlandsnäs entlang diskutiert.[2] Die Bewegung wurde von ihm als eine Verwerfung mit bedeutender Sprunghöhe aufgefasst. H. E. Johansson hat den regionalen Charakter der Dislokationslinie zuerst erkannt und ihren Verlauf in einer Übersichtskarte von 1927, die dem Geolog. Verein vorgewiesen wurde, eingezeichnet. Derselbe Verfasser hatte auch schon früher[3] im Anschluss an die Diskussion über die südwestschwedischen Manganerze, die an den hier aktuellen Mylonitzonen lokalisiert sind, die Ansicht ausgesprochen, dass die Mylonitbildung genetisch mit der Faltung der Dalformation zusammenhängt. 1937 hat

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[1] G. F. F. 59, 1937, 205.
[2] G. F. F. 41, 1919, 341.
[3] S. G. U., Ser. Ca, Nr 17, S. 24, 1924.

Magnusson in seiner erwähnten Arbeit die Verhältnisse längs der Kållandsöverschiebung aufs neue unter Annahme einer Überschiebung längs der Mylonitzone berührt. Selbst hatte ich auf dem Blatt Lidköping 1934—35 Gelegenheit, die Verhältnisse dort zu verfolgen. Die Lage der Überschiebungsebene ist — der Schieferung nach zu urteilen, die in den äussersten Entblössungen oberhalb des Vänersees sichtbar ist — relativ flach gegen Westen geneigt (20—40°). Die Überschiebungsebene selbst scheint nirgends aufgeschlossen zu sein. Die Mylonitisierung und Zertrümmerung ist in den äussersten Aufschlüssen am Ufer ausserordentlich stark entwickelt. Gegen Westen nimmt die Intensität ab, doch macht sie sich noch in einem Abstand von 1 bis 2 km bemerkbar. Gleichzeitig wird das Fallen der Schieferung steiler. Auch bei grösserem Abstand vom Ufer trifft man isolierte, kräftig entwickelte Zertrümmerungszonen. In ihrer am stärksten beanspruchten Form erscheinen die Mylonite als dichte oder feinkörnige Schiefer von dunkler oder hellerer Farbe, je nachdem das ursprüngliche Gestein aus einem Grünstein, einem grauen oder rötlichen salischeren Gneis bestand. Mineralogisch äussert sich die Mylonitisierung in Neubildung von Chlorit, Epidot und Serizit, gleichzeitig wobei etwas Kalkspat auskristallisiert hat. Dazu kommt noch in einer Zone von etwa 100—200 m oberhalb des Ufers die Ausbildung eines unregelmässigen Netzwerkes von Quarztrümmern und -adern, in denen ganz vereinzelt rötlicher Feldspat und Eisenglanz in grober Ausbildung gesehen werden können.

Dass es sich hier um eine Überschiebung handelt, ist offenbar. Wenn man die Bewegung als Verwerfung bezeichnen will, muss die Verschiebungsebene sehr flach liegen. Am ehesten können wir von einer Schollenüberschiebung sprechen. Über die Tragweite der Bewegung kann nichts näheres ausgesagt werden. Der schon von Sandegren von der Gegend nördlich des Vänersees erwähnte schroffe Gegensatz der geologischen und tektonischen Verhältnisse beiderseits der Überschiebungslinie hat sich auch auf Blatt Lidköping bewährt und deutet an, dass es sich nicht um einen ganz unwesentlichen Verschiebungsverlauf handeln dürfte, wenn wir auch H. E. Johansson darin beistimmen müssen, dass das Vorhandensein zweier verschiedenartig gebauter Gebiete zur Lokalisierung der Verschiebungsfläche zum Grenzgebiet beider beigetragen hat.[1]

Über die Verhältnisse südlich von Lidköping sind wir noch wenig unterrichtet. Ebenso sind die Umstände bezüglich der zentralvärmländischen Mylonitzone unklar. Es mag richtig sein, wie Magnusso behauptet, dass die beiden Seitenebenen des Mylonitgebietes eine gegen unten zugespitzten Keil bilden; wie aber die Tektonik und da Geschehnis im Übrigen zu deuten ist, bleibt noch ungewiss. Aus de Darstellung Magnussons scheint hervorzugehen, dass er die Mylonitzon als einen gegen unten herabgesunkenen Block auffast. Die Erklärun der Mylonitisierung und des Mechanismus der Blockbewegung biete doch unter der gegebenen Voraussetzung einer gegen unten gerichtete Auskeilung des Blockes Schwierigkeiten.

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[1] Die Verschiedenheit des Gesteinsgrundes zu beiden Seiten der Überschiebungslinie ritt auch in der Karte von G. Ljungdahl von 1922 über die magnetische Deklination nter den Anomalien bei Vänern hervor. So ist die magnetische Abweichung östlich von er Linie fast ausschliesslich gegen Westen, westlich davon gegen Osten gerichtet. Diese Tatsache wurde schon von P. Geijer in Zusammenhang mit der Dislokation gebracht Kungl. Sjökarteverket, jordmagnetiska publikationer, Nr 2, 1922).

Eine zweite Dislokationszone, die seit alters her die Aufmerksamkei auf sich gezogen hat, ist die *Grenze zwischen dem westlichen und ös lichen Schweden.* Geologisch-stratigraphisch bedeutet diese Linie eine Unterschied zwischen einem ziemlich homogen aus Gneisgraniten aufgebauten Komplex im Westen und einem bunteren aus Gneisgranite jüngeren Graniten und Leptiten aufgebauten Gebiet im Osten. Diese Unterschied auf das Konto einer im westlichen Schweden stattgefun denen spätarchäischen Metamorphose zu führen, ist meiner Meinun nach nicht richtig. Persöhnlich bin ich eher der Ansicht, dass das west liche Gebiet als eine zur Zeit der archäischen Faltung der Leptite un Urgranite entstandene Kulmination zu verstehen ist, in der das Gneis granitmagma regional relativ hoch aufgewölbt worden ist. Auf dies Frage hoffe ich bei späterer Gelegenheit zurückkommen zu könne

Es ist fraglich, ob wir längs dieser Grenze eine einheitliche Verwer fungszone haben. In der oben erwähnten Karte von H. E. Johansso und der übersichtlichen Skizze von Magnusson ist eine Verwerfung de Fluss Klarälven entlang oder in dessen Nähe bis zum Vänern einge zeichnet worden, obwohl der Verlauf der Linie auf beiden Karten etwa verschieden ist. Die auf Fig. 1 wiedergegebene Linie ist nach H. E Johansson gezogen. Weiter südlich wird in den Kartenblättern da Auftreten von zahlreichen kleineren Mylonit- und Verschieferungszone erwähnt innerhalb eines breiteren Gürtels bei Töreboda-Karlsborg un längs der östlichen Seite des Vättersees, ferner bei der Südspitze diese Sees und gegen SSO auf dem Blatt Nydala. Weiter gegen Süden sin die Verhältnisse wenig bekannt. Die Deformation des Gesteinsgrunde verteilt sich längs dieser Strecke teilweise auf breitere Gürtel mit eine Mehrzahl von kleineren Mylonitzonen. Den allerdings wenigen Angabe der Literatur nach zu urteilen, wären die Bewegungsebenen der Mylo nitzonen mittelflach bis steiler (50—70°) gegen Westen geneigt. Di Mylonitzonen zerschneiden sowohl Granite als Gneise.

Über die Verschiebungsbeträge längs der Mylonitflächen ist nicht näheres bekannt. Die Erscheinung der Zermalmung und der Myloni ebenen zeigt aber an und für sich, dass eine Bewegung stattgefunden haben muss.

Eine dritte Verschieferungszone, die in diesem Zusammenhang zu erwähnen ist, stellt die von W. Larsson[1] beschriebene *Svinesund-Kosterfjord-Überschiebung* dar, die bei der oberen (westlichen) Grenze des Bohusgranites liegt. Das Fallen ist im nördlichen Teil 20—55° und im südlichen 38—70° gegen Norden und Westen geneigt.

Magnusson erwähnt vom Blatt Säffle eine kleinere Mylonitzone, die auf der Übersichtskarte, Fig. 1 eingezeichnet ist. Allerdings soll hier das Fallen gegen Osten gerichtet sein. Vielleicht gibt es auch andere ähnliche Verschiebungsebenen, z. B. in der Gegend von der Dalformation, in Bohuslän und im südlichen Västergötland (Göta älv u. a.). Die Aufmerksamkeit der Geologen ist bisher wenig auf die Erscheinung gerichtet gewesen.

Über das Alter der angeführten Dislokationen liegen vereinzelte Annahmen vor. Im Anschluss an seine Auffassung der ostschwedischen Spaltenbildungen als subjotnisch-jotnisch hat Asklund[2] die Meinung ausgesprochen, dass die erwähnten Störungszonen im westlichen Schweden in postjotnischer Zeit gebildet oder aufs neue aufgerissen worden sind. Auch H. Martin[3] ist geneigt, der Protoginverschieferung beim südlichen Teil des Vättern dasselbe Alter zuzuschreiben.

Wenn wir vorerst die gegenseitigen Verhältnisse der drei Hauptzonen in Betracht nehmen, fällt uns auf, dass sie sämtlich einen gleichartig von Westen her kommenden regional verteilten Druck voraussetzen, was für Zusammengehörigkeit innerhalb ein und derselben Periode spricht. Dasselbe geht ferner von der Anordnung hervor. Im Grossen bilden die zwei östlichen Hauptzonen einen gegen Osten konvexen Bogen, hinter dessen zentralem hervorgeschobenem Teil die Dalformation liegt, von der wir wissen, dass eine stark dislozierende Einwirkung stattgefunden hat. In demselben, am stärksten beanspruchten Segment des Bogens finden wir weiter westlich den Bohusgranit mit der Verschiebungszone in seinem oberen Teil. Sämtliche Erscheinungen zeigen eine Anpassung aneinander, die ohne zeitliche Zusammengehörigkeit schwer verständlich wäre.

Nach Magnusson werden die zentralvärmländischen Mylonite von Kambro-Silur und Sparagmit überlagert. Sie sind darum algonkisch oder älter. Dasselbe kann wohl auch für die Fortsetzung der Kållandsö-Überschiebung behauptet werden. Nach A. Gavelin[4] ist der westliche Teil der Almesåkraformation von demselben Dislokationsvorgang mit-

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[1] S. G U Ser. C, Nr 411, 1938.
[2] Ramsay II Fennoskandias geologi, S. 369.
[3] N. J., B. B., 82, 1939, S. 36.
[4] S. G. U., Ser. C, Nr 241, S. 35, 1912.

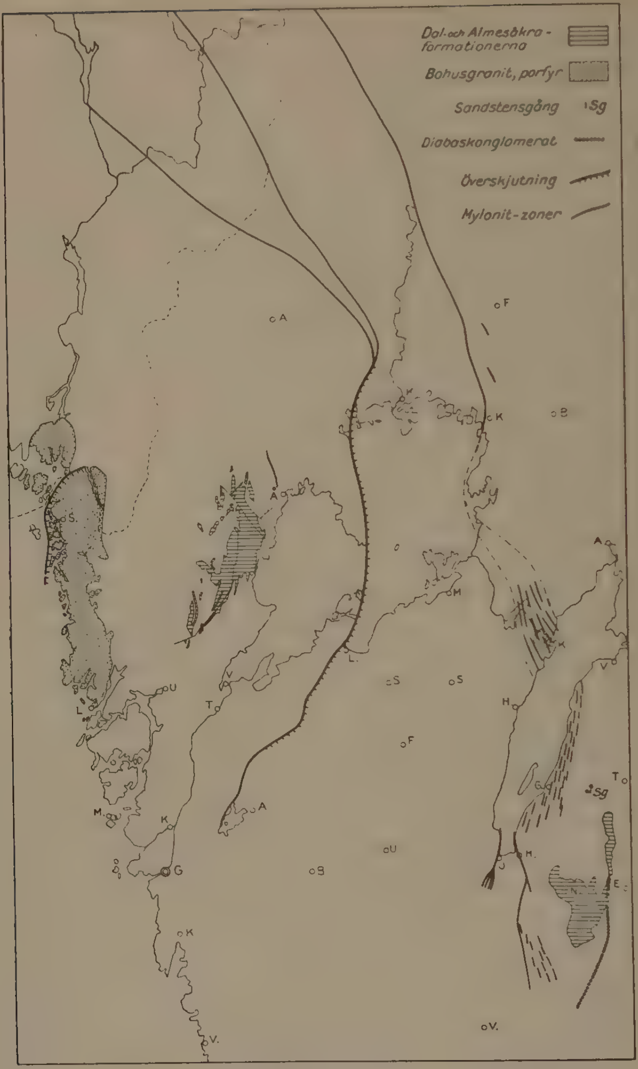

Fig. 1.

ergriffen worden, der in der Gegend um den südlichen Vättersee herum und südöstlich davon die Protoginvergneisung hervorgerufen hat. Di Altersbestimmungen der Bewegungen, die vorläufig möglich sind, deuten darum auf ein Alter, das zu nach- oder spät-Almesåkra und -Dal formation hinzuführen ist.

Die Diskussion der erwähnten Dislozierungs- und Kataklaserscheinungen führt somit zu der Frage nach dem Alter und den Faltungs vorgängen der Dalsland- und Almesåkraformationen. Von diesen dürfte letztere wohl allgemein als jotnisch aufgefasst worden sein, was wohl mit der überwiegend grobklastischen Beschaffenheit der Sedimente und deren besonders im östlichen Teil wenig oder überhaupt nicht gestörten Lage im Zusammenhang steht. Die Formation hat bekanntlich früher eine wesentlich grössere Verbreitung gehabt, was aus dem Vorkommen eines hiehergehörenden Sandsteinganges in der Gegend von Grenna[1] und von den von Eichstedt[2] und Hedström[3] beschriebenen Diabaskonglomeraten hervorgeht, die auf der Karte Fig. 1 eingezeichnet sind.[4] Aus den vorliegenden, leider noch ungenügenden Mitteilungen über die Tektonik dieses Sedimentkomplexes scheint jedenfalls hervorzugehen, dass die Bewegungen in einem frühen Stadium begonnen haben, ehe die Ablagerung der Sedimente abgeschlossen war. Nach den Beobachtungen von S. Gavelin[5] zu urteilen sind sie auch nicht ganz schwach gewesen, da sie Überschiebungserscheinungen hervorgerufen haben. Nach Martin ist die Faltung unter Voraussetzung eines von Westen her kommenden Druckes verständlich.

Auch der Dalformation mit ihrer auf etwa 2,000 m geschätzten Mächtigkeit der Lager muss ein ehemaliges grösseres Verbreitungsgebiet zugeschrieben werden. Die Formation könnte als eine Geosynklinalablagerung aufgefasst werden, wozu jedoch zu bemerken ist, dass diese jedenfalls ziemlich begrenzt und von embryonaler Art gewesen sein muss. Das Sedimentmaterial ist auch, wie Hausen[6] betont, überwiegend nicht besonders feinkörnig und zum grösseren Teil von klastischer Art. Über das Alter der Ablagerungszeit bestehen geteilte Meinungen.[7] Wenn wir von einem Vergleich mit den Sparagmiten absehen, wäre an eine Gleichstellung der Formation mit dem Jatul in Finland und im nördlichen Schweden oder mit den jotnischen Ablagerungen zu denken. Was für die erstere Annahme angeführt werden kann, ist die Faltung beider erwähnten Formationen, währenddem das Jotnium grösstenteils ungestört geblieben ist. Ferner sind die Ablagerungen des letzteren hauptsächlich grobklastisch, während die Dalformation sich lithologisch dem Jatul mehr nähert. Aber auch dieser Vergleich ist, wie wir oben sahen, (Hausen) nicht ohne Reservation geblieben. Die Frage ist also offen. Asklund hat in der letzten Auflage (1927) von Nordisk Familjebok die

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[1] A. Gavelin, op. cit., S. 7.

[2] G. F. F., 7, 1884—45, S. 610.

[3] S. G. U., Ser. Aa, Nr 129, 1917, S. 37.

[4] Ein isoliertes Vorkommen von Diabaskonglomerat am Südende des Immeln-Sees n nordöstlichen Schonen fällt ausserhalb der Karte.

[5] G. F. F., 53, 1931, S. 137.

[6] Extrait des Comptes Rend. Soc. geol. Finl., Nr 4, 1931, S. 23.

[7] Vergl. E. Ljungner Bull. Geol. Inst., Upsala, XXI, 1927—30, S. 30.

Formation als jotnisch bezeichnet. Wenn wir die Formation und ihre Faltung als jatulisch ansehen, dann müssten wir zwei orogenetische Perioden im vorliegenden Gebiet annehmen, deren Auswirkungen sich an einander genau angepasst hätten. Dies ist infolge der streng sub-parellelen Anordnung der Phänomene nicht wahrscheinlich. Ich halte darum ein jotnisches Alter für wahrscheinlicher. Die Dalformation wäre dann eine mächtigere und geosynklinalartige Entwicklung der jotnischen Sedimentbildung, die sich in dem später am stärksten mechanisch beanspruchten Gebiet des Landes abgespielt hat, während die übrige weit verbreitete, aber zu lokalen Abschnitten begrenzte Ablagerung jotnischer Sedimente grösstenteils terrigenen und grobklastischen Charakter besass. Wenn diese Ansicht richtig ist, würde die dislozierte Dalformation der Zusammenpressung der allerdings schwach entwickelten Geosynklinale entsprechen und die orogenen Ereignisse der östlicheren Überschiebungs- und Mylonitisierungserscheinungen sowie die schwächere Faltung der Almesåkraformation Vorlands-Dislokationen darstellen. Ebenso stellt die Svinesund-Koster-Verschieferungszone einen ähnlichen Zug im Hinterland dar.

Auch die Tektonik der Dalformation ist noch zu wenig erforscht. Au den Angaben von A. G. Högbom und besonders aus der kurzen Diskussion von Hausen[1] geht zwar hervor, dass der bescheidene Bau de Törnebohm'schen Darstellung den Tatsachen nicht entspricht. Im Gegenteil kann mit starker Verschuppungs- und Überschiebungstätigkeit gerechnet werden. Nach Hausen wäre diese unter Annahme eine von Westen und Südwesten kommenden Druckes verständlich. Die im hinteren (westlichen) Teil der Kette vorkommenden flachen und gege Westen gerichteten Überschiebungen (Bäcke) sind seiner Meinung nac als Rückfaltungen im späteren Stadium der Faltung aufzufassen.

Die Deformationsperiode, während der die beschriebenen Faltungs- Überschiebungs- und Mylonitisierungserscheinungen sich abgespielt haben, wäre also, wie es von Asklund behauptet wurde, am wahrscheinlichsten auf spät- und post-jotnische Zeit zu verlegen. Ob dasselbe auc für die Svinesund-Koster-Verschieferungszone streng gilt, oder ob w hier möglicherweise mit einem früheren (subjotnischen?) Beginn de Druckeinwirkung zu tun haben, mag unentschieden bleiben.

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[1] Op. cit.

Notiser.

Aktuella data angående fyndigheter och produktion av mineral.

1. *Järnmalmsbrytningen i U. S. A.*

Järnmalmsbrytningen i U. S. A. utgjorde:

1939	52,600,000 t
1940	74,900,000 t
1941	93,900,000 t
1942	108,700,000 t

Järnmalmsproduktionen har således under andra världskriget från 1939 till 1942 mer än fördubblats och 1942 nått den hittills högsta siffran.

Totalvärdet av 1942 års produktion var 280,400,000 $ och Fe-medelhalten något över 50 %.

Produktionen fördelade sig 1942 på följande distrikt:

Lake Superior	93,600,000 t
Nordöstra magnetitdistriktet	4,000,000 t
Clinton	9,600,000 t
Övriga distrikt (huvudsakligen Klippiga Bergen)	1,500,000 t
	108,700,000 t

(Glückauf 79, H 49/50 Essen $^{11}/_{12}$ 1943 s. 566.)

2. *Järnmalmsbrytningen i Sovjetunionen.*

Den sista uppgiften för Sovjetunionens järnmalmsbrytning föreligger för 1938, då den uppgick till 26,530,000 t.

(Glückauf 79, H 49/50 Essen $^{11}/_{12}$ 1943 s. 567.)

3. *Nya järnmalmsfyndigheter i Manchukuo.*

Manchukuos järnmalmsproduktion uppskattas för 1941 till $3^1/_2$—4 millioner ton.

En ny järnmalmsfyndighet ligger vid Dalitsugon nära den koreanska gränsen. Malmtillgångarna uppskattas till 78,000,000 t med en medelhalt av 63 % Fe. Brytningen började 1938.

En annan ny fyndighet vid Tszidaogon uppskattas innehålla 10,000,000 t med en medelhalt av 52 % Fe. Exploatering av denna fyndighet började 1939.

(The Mining Journal, London $^{29}/_5$ 1943 s. 268.)

4. *Spaniens järnmalms- och svavelkisproduktion.*

För 1941 och 1942 föreligga följande uppgifter om Spaniens järnmalms- och svavelkisproduktion:

	järnmalm	svavelkis
1941	1,640,687 t	494 096 t
1942	1,670 370 t	463 533 t

(Glückauf 79, H 18/19 Essen $^{8}/_{5}$ 1943 s. 265.)

5. *Världens svavelproduktion.*

Världens totala svavelproduktion var 1942 8,400,000 t. Härav utgjorde 4,400,000 t råsvavel och 4,000,000 t svavel i 9,100,000 t svavelkis. U. S. A. producerade i runt tal $^3/_4$ av världens råsvavel. Näst största producent var Italien. Åren före andra världskriget utgjorde Italiens råsvavelproduktion i medeltal per år 380,000 t.

(Glückauf 79, H 49/50 Essen $^{11}/_{12}$ 1943 s. 567.)

6. *Egyptens manganmalmsproduktion.*

Egyptens manganmalmsproduktion var före andra världskriget ganska betydande. Årsproduktionen nådde 1937 186,320 t. Under kriget har den gått ned högst avsevärt och utgjorde 1942 endast 9,000 t. Huvuddelen av produktionen har en medelhalt av 35 % MnO_2, men under sista tiden har även betydligt rikare malm brutits. Den största manganförekomsten ligger vid Um Bogma på Sinaihalvön. En annan viktig förekomst finnes vid Ras Golaam i Sydostöknen nära Röda havets kust.

(The Mining Journal, London $^{29}/_5$ 1943 s. 265.)

7. *Canadas nickelproduktion.*

Canadas nickelproduktion lär under 1942 ha varit mindre än under de sista förkrigsåren, nämligen 103,000 t gentemot 112,000 t år 1937, 106,000 t år 1938 och 113,000 t år 1939.

Nya nickelmalmsförekomster lära under sista tiden ha upptäckts i Labrador.

(Zeitschr. f. prakt. Geol. 51. H. 10 Halle-Saale oktober 1943, Lagerst.-Chr. s. 118.)

8. *Bolivias gruvproduktion.*

För åren 1940—1942 föreligga följande uppgifter för Bolivias gruvproduktion:

	1940	1941	1942
Olja	10,000 t		
Guld	366 kg		
Silver	175,000 kg	229,000 kg	
Koppar	6,660 t	7,274 t	
Tenn	37,923 t	42,740 t	38,200 t
Zink	12,205 t	6,065 t	
Bly	10,933 t	15,653 t	
Antimon	10,813 t	14,870 t	
Vismut	19 t	11 t	
Kobolt	2 t		
Volframmalm	4,183 t	2,613 t	
Asbest	70 t	210 t	
Glimmer	1 t		

(Glückauf 79, H 47/48 Essen $^{27}/_{11}$ 1943 s. 545.)

9. *Mineralfyndigheter i Honduras.*

Honduras har en icke obetydlig guld- och silverproduktion, som huvudsakligen härstammar från kvartsgångar i andesit. Den viktigaste gruvan är Rosariogruvan vid San Juancito ca 20 engelska mil norr om Tegucigalpa.

1941 var produktionen ca 710 kg guld och 108,500 kg silver. Värdet av denna produktion utgjorde 80 % av totalvärdet av Honduras mineralproduktion. Andra mineralfyndigheter av större betydelse äro två antimonförekomster i Copan-Distriktet och en nyligen upptäckt enligt uppgift stor och rik manganmalmsförekomst nära pacifichamnen San Lorenzo. Vidare planerades utvinning av kvicksilver från en cinnoberförekomst vid Talanga ca 30 engelska mil från Tegucigalpa.

(The Mining Journal ²⁹/₅ 1943 s. 268.)

10. *Sydafrikas mineralproduktion.*

Sista uppgifterna om Sydafrikanska Unionens mineralproduktion föreligga för 1939 och ha följande utseende:

	t	Värde i 1,000 $	% av totalproduktionens värde	Värdet av totalproduktionen i 1,000 $ (1880—1939)
Kol	16,501,000	4,824	7	120,645
Guld	399	54,462	83	1,756,603
Platina	2.7	302	0.5	
Platinametaller	0.2	36	0	
Silver	36.7	109	0.2	
Koppar	10,998	537	0.8	30,860
Tenn	482	93	0.1	7,632
Järnmalm	490,136	120	0.2	
Manganmalm	419,697	491	0.8	
Krommalm	160,014	348	0.5	
Svavelkis	29,825	37	0.1	
Grafit	59	2	0	
Glimmer	972	4	0	
Asbest	19,988	523	0.8	
Magnesit	4,000	9	0	
Talk	500	3	0	
Korund	22,380	18	0	
Diamant (karat)	1,249,000	2,604	4	330,376
Beryll	—	4	0	
Annat	—	1,501	2	
Totalt	—	66,027	100.00	

(Glückauf 79, H 14/15, Essen ¹⁰/₄ 1943 s. 223.)

1. *Världens diamantproduktion.*

För åren 1940—1942 föreligga följande uppgifter om världens diamantproduktion i 1,000 karat:

	1940	1941	1942
Belgiska Kongo	9,602	5,866	6,018
Brittiska Västafrika	1,575	1,850	1,850
Syd- och Sydvästafrika	576	—	166
Brasilien och Angola	1,100	1,000	1,100
Övriga produktionsområden	160	389	120
	13,013	9,105	9,254

(Z. f. prakt. Geol. 51, H 11, Halle-Saale Nov 1943, Lagerst.-Chr. s. 132.)

12. *Världens beryllproduktion.*

Som nedanstående tabell visar, har världens beryllproduktion från 1935 till 1940 nära sexdubblats. Efter 1940 har produktionen fortsatt att stiga.

	1935	1936	1937	1938	1939	1940
Argentina	208	331	287	830	329	573 t
Australien	—	—	—	—	7	2 t
Brasilien	—	4	—	223	304	1,622 t
Canada	—	20	20	10	177	— t
Brittiska Indien	139	98	27	17	9	— t
Madagaskar	11	11	2	2	—	— t
Portugal	2	2	24	—	—	— t
Sydafrika	88	5	—	—	—	— t
U. S. A.	—	—	75	25	94	121 t
Total:	448	471	435	1,107	920	2,318 t

(Z. f. prakt. Geol. 51, H 11, Halle-Saale Nov 1943, Lagerst.-Chr. s. 130.)

13. *Canadas oljeproduktion.*

Canadas oljeproduktion har under de senaste åren ökat avsevärt, som följande siffror visa:

Oljeproduktionen i 1,000 t.

1913	29	1936	192	1940	1,148
1933	147	1937	377	1941	1,298
1934	181	1938	893	1942	1,333
1935	183	1939	1,005		

(Glückauf 79, H. 47/48 Essen $^{27}/_{11}$ 1943 s. 545.)

14. *Oljeprospektering i Sydafrika.*

I Sydafrika pågå sedan några år tillbaka omfattande oljeprospekteringsarbeten i statlig regi. Efter de geologiska och geofysiska undersökningarna planerar sydafrikanska regeringen djupborrningar, bl. a. i den del av Karroobäckenets södra randområde som tillhör Kapbergens veckningsområde och vid Kestel nära Harrismith vid Drakensbergens utlöpare (NO-delen a Oranjefristaten).

(Oel und Kohle 39, H. 33/34 Berlin $^{15}/_{11}$ 1943 s. 969.)

15. *Uppskattning av oljereserver.*

I U. S. A. har nyligen följande uppskattning av vissa länders oljereserve gjorts:

	millioner ton
U. S. A.	2,850
Persiska viken	2,300
Sovjetunionen	1,210
Venezuela	780
Mexiko	100
Colombia	72
Trinidad	34
Peru	23
Canada	18

	millioner ton
Burma och Indien	22
Egypten	11
Totalt	7,500

Axelmakternas oljereserver saknas i ovanstående lista. Trots detta är oljereservernas totalsumma för de i listan upptagna länderna nästan dubbelt så stor som en uppskattning av hela världens oljereserver gjord för ca 10 år sedan ävenledes av amerikanarna.

(Z. f. prakt. Geol. 51, H 11, Halle-Saale, Nov. 1943, Lagerst.-Chr. s. 134.)

Otto Meier.

De sedimentära järnmalmerna vid Kertj på Krim.

Europeiska Rysslands två största järnmalmsfält, av vilka det ena är beläget vid Krivoj Rog och det andra på Kertj-halvön, äro av dominerande betydelse för den ryska järnmalmsförsörjningen. Båda äro välbekanta från krigsrapporterna och när tyskarna hösten 1941 erövrade dem bägge betydde detta ett allvarligt bakslag för ryssarna, vilka härigenom huvudsakligen voro hänvisade till fyndigheter i Ural. Att döma av en nyligen utkommen uppsats av H. Putzer om fyndigheterna vid Kertj (H. Putzer: Die oolithischen Brauneisenerzlagerstätten der Kertsch-Halbinsel. Zeitschrift für angewandte Mineralogie, Bd. 4, Heft 4, 1943), ha tyskarna utnyttjat tiden för geologiska studier inom dessa intressanta områden. Uppsatsen ifråga grundar sig emellertid i mycket stor utsträckning på tidigare ryska arbeten.

Malmerna vid Kertj bestå av limonit-ooliter och torde närmast vara jämförbara med minette-malmerna i Lothringen. Stratigrafiskt skilja de sig emellertid åt, då dessa senare tillhöra mellersta jura (dogger), under det att Kertj-malmerna äro tertiära (pliocen). Avvikande är vidare kornstorleken hos ooliterna, vilken hos minetterna i genomsnitt är $^1/_4$ mm, hos Kertj-malmerna är denna däremot mycket växlande, från sådana ej större än ett knappnålshuvud till »jätteooliter» med en diameter av 20—30 mm. Bindemedlet utgöres av lerigt-sandigt material, stundom med gipskristaller, som vid hög fuktighet ger massan en plastisk konsistens, men vid torkning smulas det hela sönder till grus varvid likheten med sjö- och myrmalmer blir påfallande.

Malmerna uppträda lagerformigt i smala, slutna skålar eller bäcken med kalkiga marina sediment i botten och överlagrade av sandiga lerskikt tillhörande övre pliocen. Ett sådant bäcken med Ö—V strykning upptar hela norra kustzonen mot Asovska sjön, under det att ett antal mindre sådana med SV—NÖ strykning forekomma längs Kertj-sundet. De malmförande skikten anträffas som övervägande horisontellt liggande lager på djup, som högst uppgår till 80—100 m. Mäktigheten hos desamma varierar från 1—20 m och emellanåt kunna de helt utkila.

Beträffande malmbildningens förlopp tänker sig förf. denna på ungefär följande sätt. Vid en orogenes i sentertiär tid anlades den synklinal med Ö—V till NÖ—SV strykning, till vilken de omtalade bäcken-bildningarna äro lokaliserade. Dessa senare voro till en början marina, men genom sötvattenstillflöde antogo de så småningom karaktären av laguner. De omgivande höjderna bestå av lättvittrade bergarter, huvudsakligen leror innehållande rikligt med siderit-bollar. Genom det rinnande vattnets försorg transporterades den sideritförande leran i stora massor ner i lagunerna, varest leran sedimenterade och sideriten helt eller delvis upplöstes, varefter järnet, genom inverkan av organismer, överfördes till limonit. Bildningen av de större oolitkornen ägde rum genom mekanisk pålagring, i det att smärre korn av vågorna i de grunda lagunerna rullades mot botten, varvid koncentriska skal av limonit nybildades.

Järninnehållet i dessa malmer växlar mellan 20—50 % men den genomsnittliga halten är 36 % Fe. Malmer hållande mindre än 32 % Fe anses ej brytvärda. I regel äro de manganhaltiga och kunna enligt somliga uppgifter hålla ända upp till 11 % Mn. Fosforhalten angives 0.7—1.2 % P, vartill kommer en jämn fördelning av 0.03—0.04 % V. En egendomlighet för dessa malmer är en anmärkningsvärd halt av arsenik, 0.05—0.08 % As.

Brytningen sker i dagbrott och före kriget var årsproduktionen c:a 1,000,000 ton malm. Tillgångarna äro enorma. Enligt uppgift från Geologiska Institutet på Krim skulle dessa uppgå till 1.5 miljarder ton malm. Anmärkas bör, att eftersom malmerna äro helt lokaliserade till de nämnda bäcken-bildningarna och ej förekomma utanför desamma, äro några malmreserver, förutom de kända tillgångarna, ej att räkna med.

E. Ygberg.

De kaukasiska manganmalmernas ursprung.

I häfte 1 av Zeitschr. f. prakt. Geologie för 1944 framlägger G. Berg några intressanta synpunkter på de kaukasiska manganmalmernas ursprung och uppkomst, grundade på nyare litteratur rörande en del turkiska och bulgariska manganfyndigheter.

Vid tidigare försök att tolka de väldiga sedimentära mangankoncentrationerna vid Tschiaturi och Nikopol har man utgått ifrån att manganen vid förvittringen utlösts ur den kristallina berggrunden och sedermera utfällts ur de kolloidala lösningarna, då dessa sammanträffade med saltvattnet i det tertiära hav, i vilket malmerna avsatts. En av svårigheterna, som mötte detta tolkningssätt, var avsaknaden av järnmalmer i samband med manganmalmerna trots att samtidigt med utlösningen av manganen även en flerfaldigt större mängd järn bringas i lösning. När lösningarna sammanträffa med det salta havsvattnet utfälles först manganen och därefter järnet.

Undersökningar i Mindre Asien och Bulgarien visa nu, att i ost-västlig riktning utmed Svarta Havets kust samt in i Bulgarien sträcker sig ett 1 800 km långt och 100—200 km brett bälte, som är jämförelsevis rikt på visserligen små men dock delvis brytvärda manganfyndigheter. Man urskiljer här trenne malmprovinser: tvenne av alpin ålder och en av hercynisk ålder. De flesta av de nämnda fyndigheterna äro nära knutna till andesitiska lavor och tuffer och anses bildade genom submarina exhalationer i samband med vulkanismen.

Berg framhåller nu, att dessa rena manganmalmer med sin magmatogent koncentrerade manganhalt mycket väl kunna ha utgjort ursprungskällan för de sedimentogena malmerna vid Tschiaturi och Nikopol. Fyndigheterna ha vittrat och manganen har gått i lösning, varefter förvittringslösningarna ha förts ut i lagunområden i det tertiära havet kring de nuvarande N och Ö kusterna av Svarta Havet och där utfällt sitt innehåll av mangan i form av oolitiska manganoxider.

O. H. Ö.

Anmälanden och kritiker.

H. HAUSEN: Den sulfidiska mineraliseringen (de svavlade malmerna) i Finlands urberg. — Societas Scientiarum Fennica, Årsbok — Vuosikirja XXII B n:o 1. Helsingfors 1943.

I ett föredrag inför Finska Vetenskapssocieteten den 17 maj 1943 lämnade Prof. H. Hausen en redogörelse för den sulfidiska mineraliseringen i Finlands urberg. Meddelandet innehöll en översiktlig framställning av Finlands sulfidmalmer och deras betydelse för landets försörjning med metalliska råvaror av stort allmänt intresse. Då föredraget numera föreligger i tryck men i en relativt svåråtkomlig publikation, har det synts motiverat att här ämna ett kortfattat referat beträffande de viktigaste delarna av innehållet.

Inledningsvis berör förf. några principiella frågor rörande sulfidmineralens fördelning i jordskorpan samt deras bildningsbetingelser. Med speciell hänsyn till finska förhållanden utskiljer han först de magmatiska malmerna, vilka betraktas som anslutna till ultrabasiska differentiat och härstammande ur en kiselsyrefattig magma av i huvudsak gabbroid sammansättning. Den främsta representanten för denna typ är den 1921 upptäckta nickel-magnetkis-kopparkismalmen på nordsidan av Petsamofjällen, den s. k. Kolosjokifyndigheten. Den beräknade malmkvantiteten här anses sannolikt överstiga 5 200 000 ton. Malmen håller i genomsnitt 1.7 % Ni, och 1.3 % Cu Lokalt kan emellertid väsentligt högre Ni-halter påträffas såsom i den s. k. Kaulatunturifyndigheten (ca 6 % Ni). En monografisk beskrivning av hela områdets berggrund och malmer har lämnats av H. Väyrynen. Enligt denne kan malmen betraktas som en genom rörelser i berggrunden ur magman utpressad sulfidlösning, vilken stelnat impregnationsartat i en rivningszon av betydande längd. Större malmkoncentrationer ha endast ägt rum på några få ställen. Malmen är i regel finkornig och består av magnetkis med pentlandit, kopparkis samt något magnetit.

En malm av snarlik typ, fast av betydligt mindre dimensioner, har nyligen påträffats vid Makola i Nivala socken i Österbotten. Malmkvantiteten uppskattas här till 1 000 000 ton med en medelhalt av 1.5 % Ni och 0.5 % Cu. Malmbringare är en ultrabasisk magma av närmast peridotitisk sammansättning.

År 1913 upptäcktes vid Outokumpu i Kuusjärvi Finlands största kisfyndighet. Denna ca 20 000 000 ton omfattande malmmassa har en årlig produktion, som f. n. uppgår till 600 000 ton malm och har samtidigt givit upphov till en vittutgrenad förädlingsindustri. Malmmineralen äro svavelkis, magnetkis, kopparkis och något zinkblände. Halterna äro i genomsnitt 25 % S, 4 % Cu, 1 % Zn jämte något nickel och kobolt. Ädelmetaller förekomma sparsamt men senast redovisade årsproduktion kunde uppvisa 200 kg guld och 2 000 kg silver.

Någon allsidig malmgeologisk beskrivning av Outokumpufyndigheten ha ännu ej kommit till stånd men dess sannolika genesis anses vara klar. Malme uppträder intrusivt i kvartsitiska bergarter och förmodas vara härledd u en på djupet befintlig gabbro. Hela fyndigheten har karaktär av en på ringa djup liggande lineal vars längdaxel befinner sig i ett någorlunda horisontellt läge.

Till en annan grupp av sulfidmalmer höra de pneumatolytiska bildningarna, som främst representeras av molybdenförekomsten vi Määtäsvaara i Karelen. Malmen uppträder här dels som en svag impregnation, dels som något större körtlar i en förkvartsad gnejs. Halten av molybdenglans är ytterst låg men detta uppväges av att malmen är lätt att anrika genom flotation och impregnationens volymmässigt stora utbredning Smärre fyndigheter av molybdenglans på andra håll sakna ekonomisk betydelse.

Som en tredje grupp räknas de till granitmassiv anslutna kontaktmalmerna. Viktigaste representanterna för denna typ äro Pitkäranta oc Orijärvi, båda välkända genom Trüstedts och Eskolas arbeten. Malmerna Pitkäranta, som brötos under tiden 1814—1904, äro belägna i omedelba närhet till en rapakivigranit och befinna sig i de rester av granitmassivet »tak», som ännu finnes i behåll. De äro koncentrerade till vissa smala kalkstenslager i en glimmerskifferformation. I den genom kontaktverkan delvi till skarn omvandlade kalken äro malmmineralen avsatta genom utfällning ur gaser och lösningar, vilka emanerat från rapakivimagman. Först utkristalliserades magnetit och detta så rikligt att fyndigheten främst kan gäll såsom en järnmalm. Härefter följde tennsten, vismut och scheelit, varefte kommo sulfiderna av vilka zinkbländet kvantitativt övervägde. I äldre tider brötos främst kopparkis jämte något silverhaltig blyglans och först lång senare vidtog utvinningen av zinkblände. Nyare undersökningar ha visat at ännu, trots långvarig drift, betydande förråd av zink-kopparmalm syne vara förhanden (ca 1 000 000 ton malm).

Trots rapakivigranitens stora utbredning i Finland synes den ej, föruto i Pitkäranta, ha givit upphov till några sulfidiska kontaktmalmer, oakta det på flera håll finnes kalksten nära rapakivikontakten. Förklaringen tord vara den, att övriga rapakivimassiv representera djupare snitt av jordskorpan och följaktligen »takpartierna» borteroderats.

Den andra stora kismalmsförekomsten, Orijärvi i Nyland, sättes däremo i samband med en urgranit, som intruderats i den äldre leptitseriens bergarter. Riklig skarnbildning har ägt rum, och malmens huvuddel har karaktären av en blötmalm. Gångarten är här strålsten. Större delen av denn malm är numera utbruten, men då malmaxeln stupar mot öster, torde å detta håll på djupare nivåer ännu betydande förråd av främst zinkmalm finnas tillgängliga. Malmmineralen i Orijärvi äro svavelkis, magnetkis, kopparkis, zinkblände och blyglans. De nuvarande malmförråden uppskatta till ca 600 000 ton. Malmen håller i genomsnitt 1,3 % Cu, 5 % Zn oc 2 % Pb.

Svavelkismalmer av kontakttyp intill en urgranit äro kända från de karelska skiffrarna (Jalonvaara, Otravaara, Karhunsaari, Tipasjärvi etc.). Sidostenen utgöres mestadels av sericitkvartsit. Malmerna synas ha bildats genom pneumatohydrotermala processer, i det att gaser och lösningar emanera från en djupliggande ortoklasgranitisk magma. Hit räknas även en nyupptäckt kismalm av ej omnämnd storlek i Ylöjärvi socken, innehållande kopparkis och arsenikkis med turmalin.

Rent hydrotermala bildningar äro de kismalmsgångar, vilka här och var påträffas i det finska urberget. De sakna ekonomisk betydelse men ha ett visst mineralogiskat intresse. Förf. indelar dem i 5 kategorier.

1. Blyglans-zinkblände-gångar i gammal gnejsberggrund på Ishavskusten i Petsamo. Malmföringen i dessa endast sporadiskt uppträdande gångar är ytterligt ojämn och i stort sett fattig. Gångarten utgöres av kvarts, delvis även av tungspat och kalcit.

2. Blyglans-gangar (med silver) i rapakivigranit. I Viborgska rapakivimassivet förekomma här och var sådana gångar av obetydliga dimensioner. Även på Åland (Sillskär) finnes en sadan gang, känd sedan Gustav Vasas tid.

3. Kopparkisförande kvartsgangar i de karelska grönstenarna. De karelska skifferbergarterna innehålla stora mängder amfibolitiserade gabbroida ofioliter, vilka genomsättas av talrika mineraliserade sprickor. Malmmineralen i dessa gangar äro kopparkis, pyrit, magnetkis samt något blyglans. Gångarten är huvudsakligen kvarts jämte något kalcit.

4. Guldhaltiga svavelkis-hematit-kvarts-karbonatgångar i den nordlapska granulitformationen. De bilda en självständig gångformation, helt skild från traktens med pegmatiter sammanhängande kvartsgångar. De ha anlagts på tensionssprickor ungefär vinkelrätt mot granulitens strykningsriktning, men frågan, varifrån lösningarna emanerat, är ännu ej fullt utredd. Det i vissa av norra Finlands älvar förekommande vaskguldet förmodas härstamma från dessa gangar, vilka i sig själva endast äro svagt guldhaltiga.

5. Kisimpregnation i äldre berggrund innehållande magnetisk järnmalm. Av sannolikt hydrotermalt ursprung är den kisimpregnation, som emellanåt anträffas i vissa järnmalmsfyndigheter och vilken i äldre tider förorsakade stora olägenheter vid malmens förhyttning. I Haveri järnmalmsfyndighet vid Kyrösjärvi, som för närvarande brytes, består kisimpregnationen av magnetkis och kopparkis med rätt betydande guldhalt, varför denna del av malmen genom flotation avskiljes samtidigt med järnmalmskoncentratet.

Under benämningen de syngenetiska, sekundära sulfiderna hänför förf. de regionala impregnationerna av kis i skifferberggrund av säkert sedimentärt ursprung. Dessa äro i främsta rummet grafithaltiga fylliter, motsvarande de inom Skelleftefältet förekommande, vidare kolhaltiga strålstensskiffrar samt kvartsitiska skiffrar jämte vissa karbonatiska bergartsled. Kismineralen äro huvudsakligen magnetkis och svavelkis, undantagsvis kopparkis och arsenikkis.

Vidsträckta arealer av skifferberggrund inom Karelen, Österbotten och Finska lappmarken uppvisa en svag men ganska konstant kishalt. Vid de geofysiska malmletningarna inom dessa områden ha dessa impregnationer vållat samma oreda och besvär som de av svenska malmletare föga älskade »svarta skiffrarna» i Västerbotten. Trots att kismängden i dessa bergarter belöper sig till hundratals miljoner ton, ha de mycket litet värde ur ekonomisk synpunkt, i synnerhet som kopparhalten är minimal och ädelmetaller saknas.

Ej att förväxla med de kisimpregnerade kolhaltiga fylliterna äro de kisådrade skiffrar av falbandstyp, som beledsaga nickel-magnetkis-malmen i Petsamo, vilka skiffrar enligt Väyrynen ha karaktären av vulkaniska tuffavlagringar. Av svårtydd karaktär är vidare den kishalt av falbandstyp i sericit-kvartsitiska skiffrar, som förekomma inom betydande områden av mellersta Österbotten. Eventuellt torde denna kishalt kunna tolkas som sekundärt uppmobiliserad ur de svarta skiffrarna genom tektoniska rörelser.

Slutligen förekommer som descendent bildade sulfider impregnation av kopparglans i amfiboliter och kvartsiter inom vissa delar av nordligaste Österbotten, delvis av liknande karaktär som kopparglansen i Sjangeli. I Finland sakna dessa sulfider ekonomiskt intresse.

Sammanfattningsvis kan sägas, att Finland för närvarande är självförsörjande med hänsyn till koppar, nickel, kobolt och molybden, ävensom svavel och troligen i nära framtid zink. Guld och silver produceras i stigande mängd som biprodukt från Outokumpumalmen. Brist råder främst på järn, vilken i viss utsträckning erhålles som »purple ore» ur kisbränder, samt vidare på bly, krom och volfram.

E. Ygberg.

LEGRAYE, MICHEL: Origine et formation des gisements d'or. — Liége et Paris 1942. 192 s.

Ändamålet med denna bok är, enligt förf:s förord, att lämna en exposé över världens guldförekomster, främst med hänsyn till deras bildningshistoria och geologiska uppträdande, samt att härmed söka fylla en lucka i den franska geologiska litteraturen. Författaren, som numera är professor i Liége, har tidigare haft tillfälle att studera ett stort antal guldförekomster i Nordamerika och Centralafrika och har härvid samlat en rik erfarenhet från olika slag av dylika fyndigheter.

Största utrymmet i boken ägnas förekomster av magmatiskt ursprung och endast helt kortfattat behandlas det alluviala guldets uppträdande. Inledningsvis lämnas en allmän sammanfattning av de magmatiska processerna och deras betydelse för malmbildningen, där förf. i stort sett följer Nigglis och Schneiderhöhns uppfattning. De olika typerna av magmatiska guldförekomster indelar han i tre huvudgrupper: ortomagmatiska (= likvidmagmatiska), pneumatolytiska och hydrotermala.

Fyndigheter tillhörande den förstnämnda gruppen äro sällsynta och endast tvenne exempel äro anförda. Den andra gruppen, som indelas i pegmatitiska, pneumatolytiska och kontaktmetamorfa fyndigheter, är betydligt talrikare företrädd. Den viktigaste huvudgruppen är emellertid den hydrotermala, vilken förf., i likhet med Schneiderhöhn, uppdelar i hypoabyssiska och subvulkaniska fyndigheter.

Bland exemplen på fyndigheter av hydrotermalt ursprung återfinner man en beskrivning av Boliden (huvudsakligen efter O. Ödman 1938), vilken emellertid med hänsyn till kvarts-turmalingångarna därstädes, klassificeras som ett mellanled av pneumatolytisk-hydrotermal karaktär.

Sista kapitlet ägnas Witwatersrand under rubriken »magmatiskt eller alluvialt ursprung?» Förf. ger en kort resumé av olika tolkningsförsök och urskiljer härvid tre hypoteser: 1. Guldet alluvialt, en fossil placer bildad i kambrisk eller prekambrisk tid. 2 =1, men guldet har senare utlösts, borttransporterats och ånyo utfällts i konglomeratet. 3. Guldet har tillförts genom hydrotermala lösningar och utfällts i konglomeratet. Den sistnämnda åsikten är främst företrädd av amerikanaren Graton. Förf. själv nöjer sig med att konstatera det paradoxala i att den guldförekomst, som är lättast åtkomlig för undersökningar och som lämnat det största bidraget till världsproduktionen, samtidigt är den mest hemlighetsfulla beträffande sin bildningshistoria.

Boken avslutas med statistiska uppgifter jämte litteraturhänvisningar. Den är rikt illustrerad med små enkla men upplysande kartskisser och som helhet betraktad ger boken en kanske väl ytlig men dock klar och redig framställning av guldets förekomstsätt på vår jord.

E. Ygberg.

Myllmånsforskning och humusgeognosi.[1]

Av

LARS-GUNNAR ROMELL.

Det är nu allmänt erkänt, att ett riktigt och viktigt steg togs inom markläran, när man gick över från geognosi till modern pedologi, d. v. s. när man upptäckte vad vi nu kalla jordmånen och började efter markprofilen urskilja olika jordmånstyper i stället för att som förut hålla sig enbart till jordarter och deras beståndsdelar.

En av dem som först togo det steget var den geniale danske naturiakttagaren P. E. Müller. Han kom rent av något före Dokuchaev, som man brukar ge äran som den store pionjären.

På samma gång tog P. E. Müller ett annat viktigt steg framåt av alldeles samma art. Han såg, att mull och mår äro två olika utbildningsformer eller typer av en och samma naturliga jordmånshorisont.

Förut hade man i böckerna rivit sönder en naturlig helhet så gott man kunde i dess olika beståndsdelar. Av den vanliga fibrösa måren (»råhumusen») i våra blåbärsgranskogar tog man t. ex. upp blåbärsfilten under rubriken skogsogräs och resten under rubriken humus, där man med olika namn (t. ex. Rohhumus och Verwesungshumus) skilde mellan multnande växtdelar och »jordaktig» humus (jfr Grebe 1853, s. 140, 147 och 169, och Grebe 1858, s. 163, 171 och 195). Eller man mödade sig att inom »myllan» (humusen, dit också räknades bl. a. brun rötved i träd och stubbar) skilja mellan »mullbildande ämnen», »mullsyror» och »mullkroppar» (von Post 1862, s. 41—43).

Hampus von Post strävade efter en genetisk klassifikation av organiska jordarter och lyckades bra med det, när det gällde gyttja och dy. P. E. Müller fick kanske första stöten till sitt arbete av von Post, men han gjorde på helt annat sätt än vad von Post hade gjort med »myllan». Utan att bry sig om Berzelius och Mulder och utan att bråka mycket med definitioner beskrev han skikt för skikt »forskjellige Typer for den oberørte Skovbund, betragtet som et organiseret Hele» (s. 4), bl. a. och särskilt två »Hovedtyper af humøse Afleiringer i Bøgeskove», och han såg i dem olika »Skikkelser» av en och samma sak, som han kallade bl. a. för »Humuslaget» (s. 114) eller »Humusdækket» (s. 115).

P. E. Müllers rättframma stil är så självklar, att man lätt förstår honom trots bristen på uttryckliga definitioner. Hans »Humuslag» är på modernt pedologiskt språk en jordmånshorisont. Det är icke ett lager av en viss jordart eller alls någon viss »substans». Där ingår allt som finns inom horisonten, t. ex. sand och ler, högförmultnad humus och multnande växtdelar, levande rötter, mykorrhizor, svamphyfer, maskar och andra smådjur och hela härskaran av ännu mindre varelser, en hel »Mikrokosme».

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[1] Inledningsföredrag vid diskussion i Svenska markläresällskapet den 26 november 1943 (med några tillägg).

Om humuslagrets definition och begränsning finner man hos P. E. Müller (1878) föga direkt utsagt i klara ord. I de typiska fall han bygger på ställde sig saken på följande sätt. När horisonten var utbildad som mår, var dess gräns utan vidare klar nedåt (mot blekjorden) och praktiskt taget också uppåt, eftersom det icke fanns något lager av lösa boklöv ovanpå, utan endast »hist og her nogle Bladrester» och för övrigt idel packade löv, som räknades till jordmånen och alltså till måren. När humuslagret var mull, var gränsen skarp uppåt mot det lösa lagret av »Skovens Affald», som ännu icke hörde till jordmånen (s. 9) och därför icke räknades till mullen. Endast mullens undre gräns var oskarp och måste särskilt dryftas (s. 10).

Den nordiska skolan av skogliga markforskare, i Sverige främst de till Statens skogsförsöksanstalt knutna forskarna, har följt P. E. Müllers sätt att se och byggt vidare på den grund han lade. Inom den skolan har begreppet *humuslager* blivit grundläggande, likaså dess två huvudtyper, *mull* och *mår*, som ha väl stått sig och visat sitt värde (också utanför Norden och Europa; jfr Romell och Heiberg 1931).

Man har lagt till några nya termer. Ett ord tarvades för det »Skovens Affald» man ännu icke kan räkna till humuslagret, ett ord svarande mot dem man redan hade i andra språk för skogens döda marktäcke (litter, litière, Waldstreu, alla ordagrant = strö), och härför valdes det svenska dialektordet *förna*. Det infördes först av Hesselman (1912 s. 38 och 40) under formen »skogsförna». Också för skikt inom humuslagret har man känt behov av termer: F-skikt (förmultningsskikt) och H-skikt (humusämneskikt). De infördes av Hesselman 1926. Till sist har Forsslund (1943) givit ett särskilt namn åt hela mattan ovan måren i mossrik skog (bildad mest av mossan och dess förna): stratum superficiale eller S-skikt.

Intet av de gjorda tilläggen har rubbat något i P. E. Müllers byggnad, och det hela bildar ett klart och logiskt oangripligt system, där det icke behöver bli fråga om någon sammanblandning eller förväxling av olika indelningsgrunder. Det finns särskilda beteckningar för typer av humuslager (kategorier svarande mot t. ex. markprofiltyper: podsoler, brunjordar o. s. v.) och för skikt inom eller utom den jordmånshorisont som kallas humuslagret (kategorier svarande mot t. ex. olika horisonter inom mineraljorden: blekjord, rostjord o. s. v.).[1]

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[1] Systemet tål att byggas ut vidare utan att sprängas. Under de stora typerna mull och mår kan man sätta hur många särtyper man vill, på samma sätt som man efterhand plockar in arter i ett växt- eller djursläkte (jfr Romell och Heiberg 1931 s. 581). Till sist kunde stortyperna tänkas bli onödiga; men hittills te de sig alltjämt som nyttiga och ekologiskt liksom pedologiskt som fullträffar av en benådad iakttagare (jfr Romell och Heiberg 1931 s. 576, Romell 1935 s. 4). Skikten delas vid behov i flera, kallade t. ex. övre och undre F-skikt och H-skikt eller F_1, F_2, F_3 (jfr Hesselman 1926, s. 497 och 500) och H_1, H_2 o. s. v.; allt närmast i deskriptivt syfte. Skikten kunna och böra beskrivas eller karakteriseras med några ord profil för profil eller en gång för alla för en viss urskild typ (särtyp, variant) av humuslager. Det är samma teknik, som brukas allmänt (världen runt) för hela markprofilen med dess olika horisonter. Den medger varje önskad utförlighet eller koncentration.

Begreppet förna intar en särställning, då förnan å ena sidan bildar en horisont, å andra sidan kan jämföras med en jordart (sand, lera o. s. v.), därigenom att den alltid så övervägande består av ett genetiskt enhetligt material. Förnans särställning kan icke skyllas systemet, utan ligger i sakens natur. Den är ett bland flera skäl, som tala för att icke räkna in förnaskiktet i humuslagret utan anse den horisonten som ett täcke ovanpå jordmånen.

Man kan anmärka på en del småsaker, icke minst på definitioner och definitionsförsök. För min del menar jag liksom Halden (jfr Ekström 1929), att den brukliga definitionen på jordmån bör ändras, så att det blir klart, att humuslagret alltid hör dit, om det nu är mår eller mull. Liknande justeringar skulle nog visa sig tarvas, om man tänker närmare efter, i definitionerna på några andra allmänna termer, t. ex. mark. Av Hesselmans definitioner pa specialtermer blev förnans för sträng, då det sades, att den skulle vara oförändrade döda rester. Där fattas ett ord: någorlunda eller något liknande.[1] Hesselman tänkte sig icke heller för när han tog ordet mår för en viss typ av lätt mår. Det kom lyckligtvis aldrig att slå igenom, och missgreppet är nu gottgjort genom ett beslut vid skogsförsöksanstalternas kongress i Nancy 1932 (jfr Romell 1935 s. 4, not 4). Nyligen har Forsslund varit obetänksam nog att räkna förnaskiktet till markprofilen, fastän lyckligtvis icke till humuslagret. Litet tanklös har man nog också varit, då man har talat om »mullagret» och »mårlagret». Gärna har man då med mull menat enbart mullens H-skikt (som ju också ofta bildar hela humuslagret, när det är utpräglad mull). I och för sig gör ett sådant språkbruk intet men. På samma sätt talar man på engelska utan skada ofta om blekjorden i en podsolprofil som »the podzol layer», samtidigt som man kallar podsoljordar för »podzols». Men det kan verka förvillande för den som icke har begreppen klara. Man kan tro, att här är ett lager av en jordart, kallad mull eller mår, och Tamm (1940 s. 105) har faktiskt kommit farligt nära att göra mullens H-skikt till en jordart. Däremot betyder det i princip ingenting, att det finns två namn på mår, det nordiska ordet och det tyska »råhumus», som ännu brukas i Norge och av en del författare på svenska. Det är en enkel synonymik, icke värre än att blåbär har hetat både Vaccinium myrtillus och Myrtillus nigra.

Utanför Norden har ordet förna tagits upp i Tyskland, där man saknade ett nog klart och snävt avgränsat ord för begreppet, eftersom »Waldstreu» har betytt bl. a. allt man kan raka ihop med en räfsa i skogen. Internationellt antagna vid två kongresser (den förut nämnda i Nancy 1932 och den internationella marklärekongressen i Oxford 1935) och internationellt använda (jfr t. ex. Heiberg 1939 s. 42 och Tansley 1939 s. 83) äro dels orden mull och mår (mor) med däremot svarande begrepp (tyvärr utan att uttryckligt definieras som typer av jordmånshorisonten humuslagret), dels skiktsymbolerna F och H (F-layer och H-layer, utläst om man så vill: fermentation layer och humified layer; först föreslaget av Romell och Heiberg 1931), om också endast för de två huvudskikten i mår.

Den enighet, som härigenom har vunnits om begrepp och termer, bortsett från litet vacklan i definitionerna, tycker jag är värdefull. Den är också glädjande för oss i Norden som ett erkännande åt P. E. Müllers verk och åt nordisk skoglig markforskning efter hans tid.

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[1] **Jämför definitionen hos Romell och Heiberg 1931 s. 567.**

Men enigheten är icke och har aldrig varit fullständig, ty den gamla geognostiska synen på de ting det här gäller har aldrig dött ut. I Tyskland har P. E. Müllers pedologiska syn alltid haft att kämpa med den. Ramann förstod så litet av det nya P. E. Müller kom med, att han trodde sig »handla i hans anda» (1911 s. 172), när han lät mull betyda lägre markdjurs exkrementer, alltså en beståndsdel av vilken mark och vilket markskikt som helst. Som andra sådana »humusformer» urskilde han »Moder» (finfördelade multnande rester), torv (multnande växtrester med strukturen kvar) och utfälld humus. Alla fyra sorterna voro rena materialbegrepp på samma sätt som t. ex. sand eller lera. För att, såsom han trodde, »undgå alla svårigheter» lät Ramann sedan Rohhumus betyda varje slags multnande rester ovanpå mineraljorden och ville beskriva en råhumus t. ex. så här: »Buchen-Rohhumus aus dichtem Trockentorf, darunter 3 cm dichter Moder» eller »Rohhumus des Kieferwaldes, 10 cm lockerer Trockentorf, darunter 1 cm Moder» eller »Rohhumus als dichte feinfaserige Moderschicht 2—3 cm» (s. 195).

Den gamla geognostiska syn på saken, som var Ramanns, tycks allt seda ha levat kvar i Tyskland, men definitionerna ha växlat våldsamt (se vidare Romell och Heiberg 1931 s. 572—573), så att t. ex. Albert (1929 s. 105) har givit mull en så verkligt underlig mening som humus bildad i jorden eller nedrunnen dit i lösning (i motsats till Moder, som har förts dit mekaniskt).

Den tyska humusgeognosiens system, som kan sägas sträva efter att urskilja »das Ding an sich», kunde ha varit ett riktigt grepp i princip, ifall de naturliga bildningar det gäller hade varit enhetliga material, avsatta det ena på det andra, så som när sand är lagrad på lera. I så fall hade det också varit naturligt och riktigt att bruka samma ord för skikt och för sorter, såsom Ramann och andra ha gjort. Ingen kan med skäl kräva, att ett lerskikt eller sandskikt i en profil måste kallas något annat än lera och sand. Endast ett hade man alltid kunnat anmärka på den geognostiska tendensen i humusforskningen: det är icke säkert, att det går att skilja på humussorter av olika natur med hjälp av de »höchst oberflächliche Merkmale» (Süchting 1929) som stå till buds i skogen.[1] Man kan icke göra kemi eller mikrobiologi me bara ögonen och en lupp.

Men nu är det så, att de bildningar man finner i markens humushorisont ick äro lager av något enhetligt material. De olika lagren registrera ick heller vart och ett för sig olika biologiska bildningsvillkor (såsom lera oc sand sina geologiska). Humuslagret är tvärtom en »Mikrokosme» av levand och dött, och dess olika skikt svara mot stadier i en utveckling som i sin helhet blir olika alltefter olika villkor. Därför bör man låta bli at slå ihop under ett materialnamn skikt från olika typer av humuslager. Om le också se ut att bestå mest av ett och samma material, så kan det ändå vara fråga om helt olika saker. Däremot är det sund induktion att urskilja olika typer av hela humuslagret, efter vad man kan se, såsom har gjorts av P. E. Müller och dem som ha följt honom, ty man kan i lagerföljden, rotfördelningen o. s. v. inom humuslagret på mångfaldigt sätt skönja spår av viktiga biologiska olikheter. En sådan typologi drabbas icke av Süchtings bistra kritik.

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[1] Geognostikern dömer lätt annorlunda. Orden bli genom språkets makt över tanke nära på trollformler. Man lägger gärna in i dem en kraft, de icke ha, att överlista nature och ge sanningens kärna. Man frestas att glömma sådant, som att liknämnda skikt u humuslager av olika typ ha förts ihop under samma namn efter en ytlig likhet, som ka dölja viktigare olikheter. Den mångåriga virriga diskussionen inom tysk humusgeognos bär syn för sägen och har hittills, vad jag kan döma, icke givit något annat resultat a värde. Strävandena att »förfina» humusgeognosien genom nya tricks kunna se mycke vetenskapliga ut, men äro enligt min tro principiellt dömda att misslyckas. Man ka icke heller släpa ett laboratorium med sig i skogen.

[2] För att göra klart, att det är fråga om en jordmånshorisont, är ett ord sådant som humushorisont eller varför icke myllmån bättre än ordet humuslager, som kan miss tolkas i geognostisk anda.

Det hade icke funnits större skäl numera att syssla med den geognostiska skolan, om den icke hade fått en sen nordisk avläggare vid växtbiologiska institutionen i Uppsala.

Det började med en uppsats om förna och ävja av R. Sernander (1918), där icke endast förnan med rätta, utan också med orätt måren tas som ett geognostiskt begrepp, ett visst slags material, och där frändskapen med den tyska geognostiska skolan röjes också av termen »moder» (s. 679). Sernander dryftade begrepp med måren i en mossrik skog som exempel: »Skall nu en sådan anhopning kallas råhumus eller förna? För min del skulle jag helst välja den senare beteckningen. En råhumus bör, frånsett det ifrågavarande lagrets relativt svaga humifiering, såsom hörande till torvarterna i vidsträckt bemärkelse — man räknar den ju allmänt som en 'Trockentorf' —, enligt min tanke vara av mera stabil natur och dess övergång till en annan jordart under oförändrade yttre naturförhållanden vara en tillnärmelsevis sekulär process.»

Man bör lägga märke till att »råhumus» implicite kallades jordart och att huvudskälet för att döpa om mårens F-skikt till »förna» var av spekulativ art och faller bort ifall skiktet icke antas bildat av torv.[1] Ett annat skäl var svårigheten att dra en gräns mellan mossförnan och F-skiktet. Skogsmossorna bilda, hette det, »under sig en lucker anhopning av döda skott in situ» ända ned till »nästa lager, en mull». Så är enligt andras omdöme icke allmänt fallet eller ens regel. Forsslund skriver (s. 13): »Mellan förna- och F-skikten finns i allmänhet även en tydlig morfologisk gräns. Den egentliga mossförnan är mera lucker och dess element mer eller mindre uppåtriktade, medan de multnande rester, som ingå i F-skiktet, äro mera sammanpressade och nedtryckta mot horisontalplanet.» Mitt eget omdöme blir samma som Forsslunds. Jag har också märkt att, om man varsamt luggar mosstäcket i en mossrik granskog med mår, man oftast får med sig ganska jämnt så mycket som Forsslunds S-skikt, d. v. s. den gröna mossan och mossförnan, men föga eller intet av mären. Gränsen mellan mossförnan och F-skiktet har jag funnit vara en naturlig gräns också därför, att där samlar sig efter hand granbarrförna som på ett golv. Här ser jag för min del den naturliga markytan i den lilla skog i smått, som mossan bildar, en replik av det golv man trampar, då man går mellan stammarna i skogen.

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[1] Så har på senare tid sällan någon gjort på allvar, fastän ordet »Trockentorf» har levat kvar på tyska. P. E. Müller kallade i ordnöd mår för »Torf» i den tyska upplagan (1887) av sitt klassiska verk, men bad om ursäkt för det i förordet. Mår och torv äro ju parallella bildningar, men mycket olika utom i gränsfallen. En av skillnaderna är den Sernander pekade på. Mårens skikt spegla normalt icke sekler och årtusenden med skiftande villkor, såsom skikten i en torvmark bruka göra. Måren bör hellre ses som en kompost, som i sin helhet eller till större delen lever i nutiden. I bottnen kan finnas ett smetigt H-skikt, som ofta håller träkol, men det skiktet är nog i regel det enda subfossila, och det brukar vara helt tunt utom på fuktigare mark och i gröpper mellan stenar o. d., där minnen efter äldre skogsgenerationer ha undgått branden, som födde den nya. F-skiktet och hela måren ser man sällan tjockare än 1 dm ens i urskog i Lappland utan spår av brand (jfr Arnborg 1943). När man kring Storuman och Hornavan och särskilt på öar i Hornavan kan träffa 40—60 cm mäktig och enligt Erdtman (1943) mycket gammal fibrös mår (Hesselman 1926 s. 488—500), är det fråga om sällsynta undantagsfall. Icke utan orsak brukar torv tas som en jordart, men måren räknas som en del av jordmånen. Allt sådant tycks Du Rietz glömma bort, när han nu vill döpa om måren eller dess F-skikt en gång till och kalla endera »hedtorv» (1942, s. 127 och 131).

Sernander hade fullt klart för sig, att han med sitt nämnda förslag ställde sig isolerad bland skogliga markforskare i Norden: »Härvidlag stöter jag dock mot en annan opinion av ganska enhetlig art, som t. ex. hos Hesselman fått ett prägnant uttryck i hans klarläggande skildring . . .» (s. 663). Men Sernander var eller blev icke ensam om att hänga fast vid en geognostisk begreppsbildning. Man finner rester av en sådan t. ex. i de förslag, som lades fram vid nordiska jordbruksforskares kongress i Helsingfors 1929. De bära en tydlig prägel av kompromiss mellan oförenliga synpunkter eller standpunkter, därav en klart geognostisk. Det heter t. ex. så här: »*Humus:* kollektivbenämning för de i en jord förekommande, organiska resterna av växter och djur. — Bland humusformerna märkas: förna, torv, råhumus, mår, . . . samt mull. — *Förna:* de oförändrade, döda resterna . . . — *Råhumus:* av svamphyfer mycelietrådar eller högre växter (t. ex. bärris) sammanvävt humuslager, som kan distinkt skiljas från mineraljorden. — *Mår:* en lös och lucker humusform, . . . övergångsform mellan torv eller råhumus och mull. — *Mull:* starkt förmultnad organisk substans i lucker strukturform, . . .». Det hela är icke endast inkonsekvent, utan också oklart. Ordet »humusform» definieras icke annat än genom den anförda uppräkningen, och »humuslager» definieras icke alls. Särskilt klart geognostiskt och enligt min mening olyckligt var, att råhumus, mår och mull jämställdes med förna som »humusformer» under en ren materialrubrik.

På sista åren har den tyska skolans nordiska avläggare gått till direkt angrepp mot det system P. E. Müller och den nordiska skolan av skogliga markforskare ha byggt upp på pedologisk grund. I dess ställe vill man nu sätta ett klart geognostiskt system.

Det började skenbart rätt oskyldigt med att Sernanders elev Lindquist (1931, s. 218) kallade mullens H-skikt för »mullskikt (-lager)» och mårens H-skikt för »råhumusskikt». Men 1938 var man färdig att helt följa tyskarnas, Sernanders och Helsingfors-kongressens geognostiska linjer. Lindquist skrev bl. a. (1938 a s. 18): »Olika varianter av dessa tre terrestra humusformer, förnan, mullen och råhumusen, konstituera i skilda kombinationer humustäcket i de skandinaviska skogarna. I vissa fall bildas hela humustäcket av en enda av dessa humusformer . . ., i andra fall konstitueras humustäcket av två eller tre av dessa humusformer jämte deras varianter i bestämd lagerföljd . . .». Utförligt lade Lindquist fram sitt nyordnade system i en 8 sidor lång diskussion (1938 b s. 135—143), där det bl. a. heter: »En eller flera humusformer eller skilda varianter av en och samma humusform sammansätta humusprofilen.»

Lindquist tycks icke ha fattat den grundläggande skillnaden mellan P. E. Müller och Ramann m. fl. tyskar, mellan Hesselman och Sernander, mellan jordmånslära och geognosi. Avgörande tycks han i stället finna en skillnad mellan »skiktbegrepp» och »substansbegrepp». Ändå får han Sernanders klara materialord »förna» till »i första hand» ett »skiktbegrepp». P. E. Müller råkar han helt misstolka genom att ta hans avgränsning nedåt av ett mullartat humuslager (jfr ovan s. 306) som en definition på begreppt mull. Han får på det viset också P. E. Müllers mull till ett »skiktbegrepp». Det hänger kanske samman med att Lindquist icke har fattat innebörden i det inom den nordiska skolan grundläggande begreppet humuslager. Han tycks icke ha gjort det, när han kan vilja (1938 b s. 135) jämte eller i sitt eget geognostiska system bruka bl. a. termen humuslager »i stort sett . . . i den betydelse, som angivits hos Hesselman (1926)». Liksom så många tyskar, som icke ha fattat kärnan i P. E. Müllers verk, vill Lindquist ha mullen till ett »övre skikt i mineraljorden». Och han definierar den så, att t. ex. undre delen av en riktigt präktig »Lyngskjold» på de danska hedarna, d. v. s. den av svart humus hopbeckade blekjorden, blir en utpräglad mull. Så här låter hans definition (1938 b s. 141): »det övre skikt i mineraljorden, där denna är intimt blandad med humus i sådan mängd, att inblandningen morfologiskt skiljer skiktet från underliggande icke eller obetydligt humusinblandade skikt». Ett fullständigare förnekande av P. E. Müller får man leta efter, också hos Ramann och andra tyskar.

På samma sätt ändrar Lindquist andra P. E. Müllers och hans efterföljares termer och begrepp och sätter i stället för deras nu internationellt brukade system med dess klara skillnad mellan skiktsymboler och typnamn ett unitariskt system, där samma ord brukas både för skikt och för »humusformer».

»Klarhet och konsekvens böra vara oeftergivliga krav på den indelning, som göres»; så börjar Lindquist (1938 b) sin räfst med begreppen. Men han har tagit miste om medlen till målet. Det är onödigt att ställa »skiktbegrepp» och »substansbegrepp» mot varandra, ifall det är fråga om lager av enhetligt material, såsom »humusformerna» fattas av den geognostiska skolan. Det är meningslöst och vilseledande att göra så, om det gäller att reda ut terminologien för olika utbildningstyper av en jordmånshorisont. Vad man bör skilja på är i stället skiktsymboler och typnamn.

Efter Lindquists långa diskussioner om »skiktbegrepp» och »substansbegrepp» refererar hans elev Arnborg (1940 s. 130, not 2) ett av hans huvudförslag med följande ord: »Von den drei Humusformen — Förna, Rohhumus und Mull — rechnet Lindquist zur Förna auch die Schicht, die nach eingebürgerter Terminologie als Vermoderungsschicht des Rohhumus bezeichnet wird, während er zum Rohhumus lediglich die Humusstoffschicht zählt.» Vad han här säger är, att av tre humusformer den enas undre skikt räknas till den andra.

Arnborg har varken på tyska eller svenska (1943) ställt frågan, om han bör följa Lindquist. Det tycks ha tett sig alldeles självklart, att han skulle göra det. Så är det också i doktorsavhandlingen, där »markterminologi» dryftas på 4½ sidor. Enligt den tyska resumén grundar sig också det hela på övertygelse (Ansicht).

I ett fall går Arnborg litet längre än Lindquist. Han definierar mull så, att också t. ex. en humusortsten blir mull: »Med mull förstås här ett lager i markprofilen, som består av en blandning av humus och mineraljord.» (1943 s. 46.) Men enligt vad som lär ha kommit fram vid disputationen, var det icke meningen.

Med full avsikt har däremot Arnborg i Norrland brukat en terminologi, som ger honom föga eller ingen »råhumus» i den gamla blåbärsgranskogen på torr till frisk mark, utan endast eller nästan endast »förna».

Om man söker efter sakskäl för en sådan reformiver, finner man till sin häpnad ingenting annat än att det ibland kan vara svårt att se gränsen mellan förna och F-skikt[1] och att Hesselman glömde ett ord i sin definition av ordet förna (Lindquist 1938 b, s. 136—137; jfr härovan s. 307). Utomlands måste man nog undra över att från Norden kommer ett på så ihåliga skäl[2] grundat förslag att rasera ett ur nordisk tanke sprunget klassifikationssystem med tillhörande nomenklatur och ersätta det med ett system av åldrig och tysk prägel, just som det moderna nordiska hade blivit internationellt antaget och började bli inarbetat.

Uppsalaväxtbiologerna sluta upp kring systemet Sernander-Lindquist-Arnborg. Du Rietz talade i ett utlåtande år 1940 om »ett såväl praktiskt som principiellt nytt metodologiskt grepp[3] på humusmarkprofilernas undersökning överhuvudtaget», som är »grundläggande för våra mullprofilers fortsatta utforskande». Han utvecklade saken vidare: »Man hade förut nöjt sig med att grovt indela de nordiska skogarnas humustäcke i mull och råhumus (eller mår) och endast i råhumusprofilerna urskiljt två olika humusskikt[4] med de klumpiga och föga ändamålsenliga namnen förmultningsskikt och humusämnesskikt, medan vid indelningen knappast någon hänsyn tagits till förnaskiktets utbildning.» Men med sina begrepp »som enheter vid markprofilernas analys och benämning lyckas Lindquist karakterisera dessa på ett väsentligt klarare och mera logiskt sätt än vad som förut har varit möjligt och därigenom kasta nytt ljus även över sambandet mellan markprofil och vegetation. Inom den nordiska växtbiologien har Lindquists nya grepp[5] på humusprofilernas studium redan vunnit vidsträckt användning och visat sig innebära ett metodologiskt framsteg av hög rang; själv har jag (liksom flera av mina lärjungar) i stor utsträckning använt det i de mest skilda svenska vegetationstyper från Skåne till Torne Lappmark och haft enbart goda erfarenheter därav.»

Lika enhälligt som uppsalaväxtbiologerna utan tvivel skriva under Du Rietz' omdömen, torde Nordens andra skogliga markforskare komma att skriva under Forsslunds (1943 s. 12), om också O. Hagem år 1939 i ett sakkunnigutlåtande ställde sig välvilligt avvaktande. Forsslund finner, att »den äldre terminologien» tycks »både tillräckligt klar och väl inarbetad för att böra bibehållas». Om den nya skriver han bl. a.: »Det mest beklagliga med denna nomenklatur synes mig dock icke vara själva namnen utan den brist på reda och hänsyn till materialets art, som ligger i att blanda ihop en skiktindelning och typindelning, vilja låta den förra ersätta den senare och genom nomenklaturen, om icke på annat sätt, låta en biologisk profil med olika förmultningsstadier överlagrande varandra framstå som en motsvarighet till t. ex. lera på sand eller tvärtom.»

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[1] Det skälet, som var ett av Sernanders gamla (jfr härovan s. 309), tycks Du Rietz nu icke hålla på att döma av hans förslag vid markläresällskapets sammanträde.

[2] I diskussionen tillät jag mig fråga prof. Du Rietz, om han ville komma med något verkligt skäl. I sitt svar sade han, i sak, att en eller annan skola kunde tänkas ha intresse av att söka hålla kvar en viss terminologi; men då den upsalaväxtbiologiska strävan är den motsatta, kunna hans ord väl icke tolkas som något svar på min fråga.

[3] Det principiellt nya grepp Du Rietz här talar om synes vara samma som var Ramanns år 1911, jfr citaten härovan s. 308.

[4] Också detta är redan som faktisk upplysning oriktigt, jfr definitionen av mull hos Hesselman 1926 (s. 207) och av detritusmull hos Romell och Heiberg 1931 (s. 579), vidare noten hos Romell 1934 s. 11. Du Rietz kunde också ha sett efter i »Soil notes» (s. 5, 9 och 11) i ett »Appendix» till Heibergs och min uppsats 1931 (jfr där s. 584, noten), som han enligt mina anteckningar har fått.

[5] Det vill väl säga Ramanns, jfr not 2.

Någon enighet kan alltså icke väntas bland svenska forskare under den närmaste tiden i de frågor, som här ha berörts. Om sakskäl få råda, kan icke heller i framtiden någon ny samling tänkas annat än kring P. E. Müllers linjer. Uppsalaväxtbiologernas förslag duga icke ens som diskussionsbas. Det beror icke på sådant som att definitionerna på mull leda till sådana konsekvenser att man omöjligt kan ha tänkt sig dem när definitionerna ställdes upp (jfr härovan s. 311), utan på att förslagen bygga på principiellt oriktig grund och innebära ett förnekande av den skogliga marklärans grundläggande vinningar. De måste anses ägnade att göra skada ur praktisk, vetenskaplig, svensk och nordisk synpunkt.

En god sak kunde ändå den uppsalaväxtbiologiska ivern föra med sig, om den kunde nog i grund diskreditera ordet »råhumus». Skulle på så vis enighet kunna vinnas kring ordet *mår* för P. E. Müllers begrepp, så vill jag för min del tacka för hjälpen.

I väntan på att framtiden skall ge mig rätt har jag f. n. endast ett praktiskt förslag till ändring eller jämkning, nämligen att få bort den kanske menlösa, men ledsamma homonymien mellan myllmånstypen mull (P. E. Müller) och »mull» = humusämnen. Man kunde ersätta »mull» i den sist nämnda meningen med myllämnen, mullhaltig med myllhaltig o. s. v. Jag tycker, att det borde gå bra, då ordet mylla i dagligt tal och bland praktiskt folk borde vara det vanligaste inom hela ordgruppen, och då av ålder just det ordet har brukats för humus och humusrik åkerjord. Nordiska skogliga markforskare skulle bli mycket tacksamma, om de ensamma finge rå om ordet mull som markterm, och de göra i sin tur icke anspråk på ordet mylla eller några ord bildade av det annat än den allmänna term myllmån jag härovan har föreslagit.

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Notis.

Meteorsten fallen vid Hallingeberg.

Den 1 februari 1944, kl. 14, föll en meteorsten vid Hallingeberg i Kalmar län, 25 km VNV om Västervik. Ljudet av den fallande stenen uppfattades av ett flertal personer i trakten, men hittills har inte någon uppgift inkommit att meteoren iakttagits.

Två timmar efter nedslaget påträffades stenen av en lantbrukare i Hallingeberg. Den låg på c:a 35 cm djup, och den observerades tack vare den kraterformade fördjupning, som bildats vid nedslaget. Upphittaren var inte strax klar över stenens beskaffenhet, och han slog därför sönder den. Genom förmedling av fil. mag. Nils Holmberg vid Gamleby folkhögskola ha skärvorna överlåtits till geologisk-mineralogiska institutionen i Lund.

Stenen är en järnfattig, grå kondrit med relativt jämn yta. Tre brottstycken på 685, 480 och 255 gram passade väl samman och bildade större delen av stenen. Då den lucka, som fanns kvar att fylla, troligen upptagits av en enda skärva eftersöktes denna på fyndplatsen, och den påträffades fem veckor efter nedslaget. Denna fjärde skärva vägde 36 gram. Sammanlagda vikten av de erhållna brottstyckena är således 1.456 gram.

Den kondritiska strukturen är synnerligen väl utbildad i stenen, bättre än i övriga i Sverige påträffade meteoriter.

Assar Hadding.

Mötet den 2 mars 1944.

Närvarande 47 personer.

Ordföranden, hr Ödman, meddelade, att styrelsen till nya ledamöter av Föreningen invalt:

Professor Bo Hellström, Djursholm, föreslagen av hr Caldenius,

Direktören jur. kand. E. Tunhammar, Stockholm, föreslagen av hrr Ödman och Helmer Hedström,

Ingenjör Patrik Danielsson, Stockholm, föreslagen av hrr Tor Hagerman och Helmer Hedström,

Fil. mag. Sten Rudberg, Uppsala, föreslagen av hrr Collini och Hörner,

Assistentgeologen vid N. G. U. mag. scient. Henrich Neumann, Oslo, föreslagen av hr Ödman, samt

Amanuensen fil. mag. Gunnar Wennberg och fil. kand. Nils Linnermark, Lund, föreslagna av hrr Hede och Mohrén.

Revisionsberättelse över styrelsens och skattmästarens förvaltning under 1943 föredrogs, varefter av revisorerna tillstyrkt ansvarsfrihet beviljades.

Sammandrag över Geologiska föreningens räkenskaper för år 1943.

Debet.

Balans från 1942: Reservfondens konto	kr.	11 231: 63		
Lotterifondens konto	»	8 000: —	kr.	19 231: 63

Inkomster under år 1943:

Reservfondens konto, räntemedel	kr.	336: 98		
Lotterifondens konto, »	»	357: —		
Annonser	»	378: —		
Trycknings- o. korrigeringsbidrag	»	1 602: 88		
Försäljning av föreningens förhandlingar	»	581: 95		
Statsbidrag	»	1 600: —		
Bidrag av Jernkontoret	»	1 000: —		
Portoersättningar	»	42: —		
Årliga ledamotsavgifter	»	3 760: 50		
Inbetalda ständiga ledamotsavgifter	»	300: —	kr.	9 959: 31

Utgående balans:

Skuld till P. A. Norstedt & Söner för tryckning	kr.	2 337: 76
Summa	kr.	31.528: 70

Kredit.

G. F. F. 1942, rest å tryckning			kr.	2 036: 33
G. F. F. 1943, tryckning betald	kr.	6 472: 66		
G. F. F. » » ogulden	»	2 337: 76		
G. F. F. » klischéer	»	1 315: 62		
G. F. F. » referat	»	15: 20		
G. F. F. » revue annuelle	»	351: 25		
G. F. F. » distribution	»	254: 82	»	10 747: 31
Expeditionskostnader	kr.	373: 73		
Sammanträden	»	389: 70		
Diverse (brandförsäkring, representation)	»	100: —	»	863: 43
Arvoden			»	1 350: —
Utgående balans till 1944:				
Reservfondens konto	kr.	11 531: 63		
Lotterifondens konto	»	5 000: —	kr.	16 531: 63
		Summa	kr.	31 528: 70

Föreningen beslöt ingå med ansökningar dels till Kungl. Maj:t om ett statsbidrag å 2 000 kronor, dels till hrr fullmäktige i Jernkontoret om ett anslag av 2 000 kronor såsom bidrag till fortsatt utgivande av Förhandlingarna under år 1944.

Hr Sven Gavelin höll ett av kartor och ljusbilder belyst föredrag om Några nya data om vargforsformationen och dess relationer till angränsande intrusivbergarter. En uppsats i ämnet kommer att inflyta i ett följande häfte av Förhandlingarna.

Hr Ödman höll ett av kartor, ljusbilder och stuffer belyst föredrag Om sjöfallssandstenens geologi.

Med anledning av de båda föredragen yttrade sig hrr Geijer, A. Gavelin, Asklund, Grip och föredragandena.

Hr Asklund fann det lyckligt, att de bägge föredragen framförts samtidigt, ty därigenom erhölls ett gynnsamt tillfälle att betrakta likheter och olikheter mellan geografiskt vitt skilda led av vad som numera sammanföres till den s. k. Vakkoformationen.

Det av Gavelin utforskade Skidnäsområdet motsvarar ju den tidigare i den geologiska diskussionen omnämnda Ledvattnetförekomsten av Vargforsformationen. Under en exkursion år 1927 tillsammans med Alvar Högbom och Josef Eklund hade tal. studerat förekomsten. Därvid hade rullstensmaterial av Revsundsgraniten befunnits ingå i konglomeraten, varom föredraganden i dag lämnat en utförlig, betydelsefull framställning. Vargforsformationens diskordans gentemot underlaget är sålunda enligt Skidnäsområdets vittnesbörd högst betydande: formationen har tydligen utbrett sig över en djupt neddenuderad blandad berggrund, i vilken ingått material från det lappländska urbergets tvenne arkeiska granitformationer, urgraniterna och de medelarkeiska graniterna av den stora grupp, som i Finland brukar betecknas som centralgraniter. Föredraganden hade i dag jämväl demonstrerat, att Skidnäsförekomsten genombrytes av en yngre granitgrupp, Sorselegraniten, och dennas porfyrer. Vid studiet av de förevisade stufferna av dessa yngre graniter och porfyrer frapperades man av dessas stora likhet med subjotniska eruptiv, t. ex. granitporfyrens likhet med Garbergsgraniten osv.

När tal. år 1927 studerade Vargforsformationen hade han dessförinnan under samma sommar ägnat en nära nog två månader lång resa åt jatul- och kalevformationerna i Finland, varvid bl. a. ingått fältstudier norr om Uleträsk och Kemiområdet. Trots de finska geologernas nuvarande uppfattning att kalev- och jatulbildningarna böra sammanfattas till en formation, Karelformationen, kunde man enligt tal. inom hela Finland tydligt isärhålla jatulen som en avgränsad enhetlig formation, vilken medelst en djupgående diskordans är skild från äldre urbergssediment m. m., som emellertid på otillräckliga grunder hopslagits med jatulbildningarna.

Med de färska intrycken från Finland blev det tal. klart att motsvarigheter till Nordfinlands jatul kunde förmodas dels i Övre Haukiserien inom Kirunafältet och dels framförallt i Vargforsformationen i Västerbotten. Till stor del motsvarade såväl de enskilda sedimenten som lagerföljderna varann å ömse sidor den politiska gränsen.

Beträffande den i dag skildrade Sjöfallssandstenens förhållande till sitt underlag kunde man enligt tal. ej undgå att bemärka den högst väsentligt skilda valör dess av dr Ödmans beskrivna undre diskordans äger i förhållande till Vargforsformationens. Överdirektör Geijers påpekande att kornmaterialet i sedimentlagren härstammar från djupbergarter är mycket intressant, men det oaktat ingå ju ej några djupbergarter bland konglomeratens rullstenar. Diskordansen är egentligen föga framträdande. Tal. ville därför reservera sig mot Sjöfallssedimentseriens placering i Övre Hauki-Vakkoformationen och i synnerhet emot dess sammanförande med Vargforsformationen. Denna reservation ville tal. även utsträcka att gälla de redan tidigare till Vakkoformationen hänförda kvartsitkonglomeratbildningarna vid Hippainen och Paurankivaara (i anslutning till Soppero-Rautasakaraområdet).

Än mera torde enligt talarens mening denna reservation gälla de av dr Grip med Vargforsformationen parallelliserade konglomeratlagren i Pite skärgård m. fl. lokaler vid den bottniska kuststräckan, beträffande vilket område Grip även synts benägen att utvidga den yngre sedimentserien till att omfatta därvarande skiffrar och kalkstenar m m. I området kunna emellertid där förekommande granitmassiv av Revsundstyp förväntas komma att erbjuda impertinenta överraskningar för en dylik tolkning.

Den bland »Lapplandsgeologerna» alltmer framträdande samstämmigheten däri att alla de lappländska sedimentserierna med djupbergartsrullstenar skulle tillhöra en enda formation, fann tal. bygga på en alltför schematisk uppfattning för att denna skulle äga sannolikhetens prägel. Erfarenheten från Finland, t. ex. Centralfinland med dess djupbergsartförande konglomerat, i jämförelse med de jatuliska konglomeraten av vida yngre ålder, mana till stor försiktighet i den diskuterade frågan.

Hr Grip: De områden med vargfors-, sjöfalls- och vakkoseriernas bergarter, som föredragshållarna ha parallelliserat, ligga på stora avstånd från varandra, och det kan därför vara av vikt att få ett tätare nät av observationer. Tal. ville därför nämna några nya konglomeratlokaler, som fylla sådana luckor.

Kring landsvägen, som går fram till Lövnäs vid södra änden av sjön Rappen norr om Arjeplog, ligga stora mängder med konglomeratblock, vilka torde vara ganska lokala. De förtjäna en närmare undersökning.

Skollorna i fjällranden kring Storlaisan innehålla bl a överskjutna partier av det urberg, som underlagrar fjällrandens bergarter. Där finns graniter, arvidsjaurporfyrer och konglomerat i olika utbildning. Det senare har antagits höra till sparagmitserien, men kan möjligen höra till vargforsserien. Konglomeratet är nämligen mycket likt vargforskonglomeratet och åtföljes liksom detta av röda sandstensartade bergarter av samma utseende som de S. Gavelin i dag beskrivit från Gråbergsområdet och som där visat sig vara sura vulkaniska askor. En mikroskopisk undersökning av sådana bergarter från skollorna torde kunna ge svar på frågan vart de skola hänföras. — En undersökning av de nära nog okända skollorna vidare norr ut kanske också kommer att visa nya förekomster av urbergssediment.

Pitekonglomeratet hade tal. för några år sedan beskrivit och jämställt med vargfors- och vakkoserierna. Sedan dess hade tal. funnit konglomeratet längre norr ut i såväl block som häll från Gäddvik och fram till Bälingsberget 12 km WNW om Luleå.

Till slut ville tal. göra ett förtydligande. Dr Asklund har i »Geologische Jahresberichte 1942» bl a refererat tal:s uppsats om Pitekonglomeratet och anfört att linagraniten genomsatte sediment som tal. uppfattade såsom samhöriga med konglomeratet. Tal. ville nu framhålla att linagraniten också skarpt genombröt de mest polymikta konglomeraten.

Vid mötet utdelades nr 436 av Förhandlingarna.

Mötet den 13 april 1944.

Närvarande 48 personer.

Ordföranden, hr Ödman, hälsade aftonens föredragshållare, dr Ödum, och aftonens övriga gäster, medlemmar av Svenska Teknologföreningens avdelning för kemi och bergsvetenskap, samt anförde:

»Sedan vårt senaste sammanträde ha trenne av Föreningens ledamöter avgått med döden.

Professor Dr K. Keilhack avled den 10 mars i Berlin vid en ålder av 86 år. Keilhack hade bakom sig en lång och framgångsrik bana som forskare och praktisk geolog. Hans stora lärobok »Praktische Geologie» var på sin tid den förnämsta inom denna del av geologien. Vidare var han under en lång följd av år utgivare av Geologisches Zentralblatt. K. var bl. a. Ehrenmitglied vid Tekniska Högskolan i Charlottenburg. Sedan 1884 tillhörde han vår Förening och var vid sin död dess äldste medlem.

Professor emeritus Karl Axel Grönwall avled den 12 mars i Lund id en ålder av 75 år. Han föddes i Ystad samt studerade vid Lunds niversitet. Grönwall började sin bana som paleontolog vid Mineralogisk Museum i Köpenhamn men övergick sedermera till Danmarks eologiske Undersögelse. Under detta skede publicerade han betydande rbeten över Bornholms geologi. År 1910 blev G. geolog vid Sveriges eologiska undersökning. Han togs här snart i anspråk för vissa spe- ialutredningar rörande kaolin- och kritbildningarna i NÖ Skåne samt e skånska djupborrningarna, vilkas vetenskapliga ledare han blev. r 1917 tillträdde G. professuren i geologi och mineralogi vid Lunds niversitet, på vilken post han förblev till 1934. Av Geologiska före- ingen var han ledamot sedan år 1892. Under åren 1914—16 tjänst- jorde han som Föreningens skattmästare.

Bergsingenjör Felix Wanjura avled den 1 april i en ålder av 73 år. Han var född i Tyskland men fick sin utbildning i Sverige. Efter några rs arbete i Oberschlesien var han under 20 års tid verksam i Koskulls- ulle. Av vår Förening var han medlem sedan år 1914.

Jag lyser frid över de bortgångnas minne.»

Till ny ledamot av Föreningen hade styrelsen invalt fil. stud. Nils arklund, Uppsala, föreslagen av hrr Collini och Ljungner.

Hr Ödum höll ett av talrika ljusbilder belyst föredrag om *Dan- arks geologiske Undersögelses Borearkiv, dets rganisation, Arbejdsmåde og en Del af dets Re- ultater gennem 18 År.*

Borearkivet. Så længe, der har existeret geologiske museer, ller anstalter i lighed med S G U, har geologerne indsamlet og op- egnet oplysninger om boringer, der gav indblik i jordlag o. a., som ikke ar umiddelbart tilgængeligt; det har naturligvis også været tilfældet Danmark. Bliver man stående paa dette standpunkt: at indsam- ngen af borings-oplysninger er et indre-geologisk museumsanliggen- e, kommer man imidlertid til kort på tre punkter:

) Man kommer kun i besiddelse af få og tilfældige oplysninger og pröver fra de mange boringer, der udföres med vidt forskellige formål;

) et sådant mangelfuldt borearkiv er kun i ringe grad egnet til at opfylde sine praktiske funktioner i samfundet;

) benyttelsen af boringerne i videnskabelige publikationer bliver tilfældig; der opstår jævnligt misforståelser eller tvivl m. h. t. boringers identitet og placering (fremgår tydeligt af den ældre geol. litteratur).

I et levende, moderne samfund udföres der mellem år og dag sa mange boringer, at varetagelsen og arkiveringen af de tilvejebragte oplysninger ikke længere kan betragtes som en privatsag, — hverken for geologen eller den, der lader boringen udföre. Der prövebores efter malm kul, gas, salt, olje, ler og andre råstoffer, og först og fremmest efte det værdifuldeste og uundværligste af jordens råstoffer: vand. Alle de oplysninger af geologisk art, der herved tilvejebringes, er af den störst værdi i nationalökonomisk henseende. Det gælder ikke alene de tilfælde, hvor en boring straks giver det önskede resultat, men i lige sa höj grad de tilfælde, hvor man ikke finder det eftersögte råstof; en »forgæves» boring giver i alle tilfælde oplysning om geologiske forhold der — direkte eller indirekte — er af stor værdi, enten umiddelbart (f. ex ved udredning for vanddomstolen) eller om 5—10—20 eller 50 år. — Ser man på de meget store pengebelöb, der hvert år anbringes i såve resultatrige som resultatlöse boringer, står det klart, at det er spild a samfundets midler, hvis ikke alle tilvejebragte oplysninger arkivere på en sådan måde, at de når som helst med kort varsel kan nyttiggöres i en eller anden sammenhæng.

Det skal nu være min opgave at göre rede for, hvorledes man i Danmark har sögt at löse dette problem.

Opgaven falder i 3 led: 1) Tilvejebringelsen af materialet, 2) Opbevaring deraf, 3) Ordning af det opbevarede materiale på en såda måde, at det er lettilgængeligt og brugeligt til et hvilket som hels formål.

1) Tilvejebringelsen af materialet er i Danmark sikret ved lov for d allerfleste boringer, ud fra de motiver, jeg nævnte til indledning. Lovbestemmelserne dækker tre kategorier af boringer.

I »Lov om Efterforskning og Indvinding af Råstoffer i Kongerige Danmarks Undergrund» ($^{19}/_{2}$ 1932) bestemmes, at alle boringer — d. v. s. dybdeboringer — indenfor lovens ressort skal indberettes til o fölges af D G U, som har ret til alle oplysninger, udtagning af pröve o. s. v. Bestemmelsen dækker altså boringer efter salt, olje o. a. råsto fer, som indtil 1932 ikke var indvundet i Danmark.

Ved justitsministeriel bekendgörelse af $^{13}/_{8}$ 1939 bestemmes det, a boreentreprenören er pligtig at indsende alle oplysninger om udfört gasboringer til D G U.

I »Lov om Vandforsyningsanlæg» ($^{31}/_{3}$ 1926) bestemmes det at »ve udförelsen af boringer, der anbringes i vandindvindingsöjemed, sk den, der lader boringen udföre, til D G U indsende meddelelse om boringernes beliggenhed, de forefundne jordlag, vandstanden og resu tatet af afholdte prövepumpninger».

Disse tre bestemmelser dækker alle egentlige boringer med undtagelse af boringer efter råstoffer, der ikke falder ind under undergrundsloven; og det vil i realiteten sige boringer efter alle hidtil kendte råstoffer såsom ler, kaolin, bornholmske kul, tertiærtidens brunkul o. l. Her er altså et beklageligt hul i lovbestemmelserne, men det opvejes i realiteten ved, at boringer af denne art kun udföres af et begrænset antal industrielle foretagender, entreprenörforretninger o. l., altså under sådanne forhold, at det dels er let for D G U at holde kontakt med de pågældende og få borerapporterne tilstillet, dels således, at vedkommende eftersögningsarbejde ligefrem udföres i samarbejde med D G U under en eller anden form.

Langt værre er det hul i vandforsyningsloven der ligger i den bestemmelse, at boringen skal indberettes af »den, der lader boringen udföre». Den pågældende grundejer eller arbejdsgiver er meget ofte helt uvidende om loven, eller han er ganske uinteresseret i at efterkomme bestemmelsen, — og i begge tilfælde sker der ham intet! Lovens vise fædre har ganske glemt at indföje straffebestemmelser for overtrædelse af loven (kun hvis boringen udföres for vandværker eller industrien således, at den pågældende — for at opnå vandindvindingsret — skal indbringe hele sagen for vanddomstolen (i Danmark en landvæsenskommission), kan denne sidste forvisse sig om situationen og kræve loven respekteret). Boreentreprenören — en bröndborer eller et ingeniörfirma — som er den eneste sagkyndige, har ingen forpligtelser i denne retning.

Imidlertid er D G U jo interesseret i at få så korrekte og fyldige oplysninger som muligt, og d. v. s. at man önsker at få oplysninger — og jordpröver — direkte fra entreprenören. I praksis har D G U derfor lige fra lovens ikrafttræden sat alt ind på at opnå et intimt samarbejde med alle landets bröndborere og borefirmaer. Af sådanne findes der måske en ca. 150 af en sådan standard, at man behöver at regne med dem, og fra D G U's side har man sögt at bevæge disse til frivilligt at indsende oplysninger og borepröver til D G U. Arbejdet baseres dels på et ducörsystem, hvorefter bröndborerne betales for den extra ulejlighed, de har ved indsendelsen, dels på en saglig propaganda, der tilsigter at oplyse bröndborerne om de store fordele, de kan have af et intimt samarbejde med geologerne (mere herom senere).

I realiteten har denne politik fört til et gunstigt resultat, og hvad der ikke indgår på denne vis, söges indhentet ved regelmæssige besög hos landets bröndborere, besög på borestederne under arbejdets gang, — og endelig ved mere systematiske egnsundersögelser, hvor geologerne indsamler oplysninger om tidligere udförte boringer, konstaterer terrænkote, måler grundvandsstanden o. l.

Alt dette overvåges ved en gennemfört statistik over indgangen af boringer til D G U, hvorved der skelnes mellem boringer, der indgår eller indsamles ad forskellige veje. — Ser man bort fra krigstidens kul- og gasboringer, samt boringer indsendt af det koncessionerede »Danish American Prospecting Co»[1], viser det sig, at ca. 22 % af de indgåede boringer »indsamles» af geologerne, ca. 56 % indsendes af bröndborene, og kun ca. 22 % direkte af indsendere, der er forpligtet iflg. loven. Disse sidste 22 % repræsenterer udelukkende större kommunalsamfund og större industrier med egne teknikere; næsten alle mindre vandværker, mejerier, mindre virksomheder og private overlader det hele til deres boreentreprenörer, der altså kommer ind med de ca. 56 %.

Iövrigt viser kurven en stærk stigning i årene lige efter 1926, d. v. s. efter vandforsyningslovens ikrafttræden og borearkivets organisation. Svingningerne i de senere år skyldes dels öget borevirksomhed i de nedbörsfattige år, dels nedsat borevirksomhed p. g. a. krigens materialemangel, dels vexlende aktivitet fra D G U's side. — Ialt indeholder borearkivet (BA) pr. $^{31}/_{12}$ 1943 oplysning om ca. 26 000 boringer.

2) Opbevaring af materialet. BA omfatter först og fremmest alt indsendt originalmateriale: rapporter over hver enkelt boring med alle detailoplysninger om beliggenhed, jordart, vandrejsning, prövepumpning (alt dette evt. ledsaget af korrespondance forud for og under boringens udförelse), evt. vandanalyse og endelig bjergartspröver; evt. suppleres disse oplysninger med geologens optegnelser på stedet. Alt ordnes efter löbenr., som det fremgår af det fölgende.

3) Ordning af materialet. Hele dette yderst heterogene materiale må imidlertid bearbejdes og bringes i ensartet form, hvis det skal være let håndterligt og overskueligt. Systemet er således: Efter undersögelse af borepröver m. v. rentegnes boreprofilet på et særligt profilblad, hvorpå alle vigtige data angives. En standardiseret farvesignatur letter den geologiske oversigt: blader man i de bind, hvori profilbladene samles, er et enkelt blik tilstrækkeligt til at orientere geologen m. h. t. boringernes dybde og geologiske forhold. Boringen forsynes med et löbenr. indenfor det pågældende atlasblad (1 : 40 000), og dette nr. indföres med rödt tusch på atlasbladet, hvor boringens nöjagtige beliggenhed afmærkes. Atlasbladet har sit eget nr., så slutresultatet bliver et toleddet löbenr. En boring i Köbenhavn kommer f. ex. til at hedde 201.159, og dette nr. anbringes iöjnefaldende på alt, hvad der har med den pågældende boring at göre: atlasblad, profiltegning, originalpapirer, korrespondance, bjergartspröver, analysekort o. s. v., og alt indordnes i arkivet efter dette nummersystem, der altså i virkeligheden er et geografisk system. Nummersystemet er så elastisk, at nye

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[1] Det drejer sig her ikke om dybdeboringer.

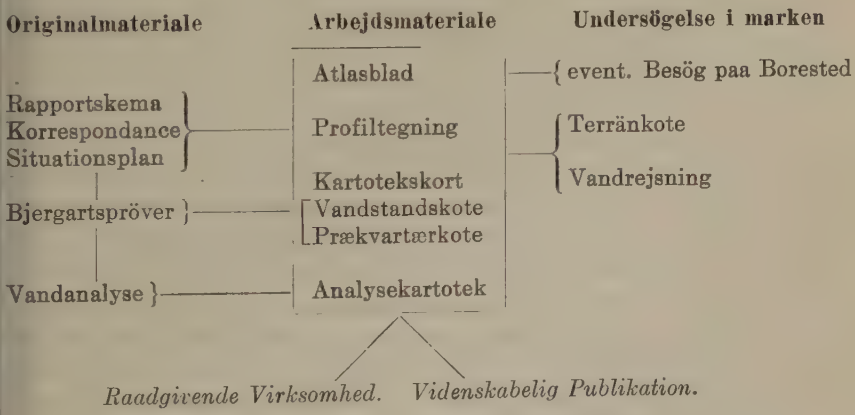
nr. kan indskydes mellem de gamle når som helst. Har en fabrik f. ex. en boring nr. 201.159, og der senere udföres en eller flere nye boringer på samme fabrik, får de blot nr. 201.159 a, b, c, o. s. v. — Nye borepröver indordnes på samme måde ved parallelforskydning af kasserne i prövemagasinet. Det kan tilföjes, at dette nr.-system nu også anvendes i al geologisk litteratur i Danmark. Enhver boring, der publiceres i en eller anden sammenhæng, betegnes med sit nr. i D G U's BA, så al forveksling eller tvivl om dens identitet udelukkes. Atlasblade + profilblade udgör BA's arbejdsmateriale, der anvendes til daglig.

For de boringers vedkommende, der giver oplysning om prækvartærets niveau og grundvandstanden, extraheres disse to koter til indförelse på et særligt kartotekskort; disse kartotekskort er lette at overskue, let håndterlige ved revision i marken, og de kan umiddelbart anvendes som manuskript ved publikation af undergrundskort og vandrejsningskort.

Et særligt kartotek föres over vandanalyser. Hvad enten analyserne kommer udefra eller udföres af D G U's kemiske laboratorium, bliver de omregnet til ensartet fod: angivelse af mg/l og milliækv./l, og dette sidste optegnes endvidere på kortet i grafisk form. Et enkelt blik på analysekortet er da tilstrækkeligt til at oplyse om såvel vandtypens art som oplösningens koncentration.

Skematisk tager BA's hele organisation sig altså således ud:

Danmarks Geologiske Undersögelse.
Borearkivet.



Vi har nu altså et BA, hvor alt er udkrystalliseret i standardiserede, let overskuelige profilblade, og hvor nr.-systemet tillader en forvexlingsfri identifikation af hver eneste boring. Nu er alt borematerialet let at benytte, — og hvortil benyttes det så?

Borearkivets Funktioner. BA's officielle funktion er först og fremmest at være til rådighed for vanddomstolene. Den danske vandforsyningslov sætter ret snævre grænser for fri og ukontrolleret indvinding; så snart det drejer sig om vandværker eller vand til selv ret små virksomheder som f. ex. gartnerier, mejerier — for slet ikke at tale om större industrier — skal indvindingstilladelse indhentes i form af vanddomstolens kendelse, og denne kendelse giver samtidig beskyttelse imod uberettiget konkurrence om grundvandsressourcerne, forurening af grundvandet m. m. Det er selvklart. at vanddomstolen ofte ikke kan nöjes med oplysninger om den ene boring, hvis ejer söger indvindingsret; den må til belysning af forholdene inddrage alt tilgængeligt materiale vedrörende hele egnens geologi og grundvandsforhold, og det er her BA's opgave altid at kunne stille alt i tidernes löb tilvejebragt materiale til rådighed. Ofte tilkaldes geologen som sagkyndig til vanddomstolen.

Denne officielle funktion er imidlertid ikke den eneste, ja ikke engang den mest omfattende. Langt den störste opgave ligger i at fungere som oplysningscentral for alt, hvad der har med den geologiske side af vandboringer at göre. Alle bröndborere og alle vandværksbranchens ingeniörer har hurtigt opdaget, hvilken stötte de kan have fra BA's side, og da BA fra förste stund har fulgt det princip så vidt muligt at svare på alt, hvad man kunde svare på, beredvilligt og uden bureaukratiske omsvöb, vil det forstås, at der har været basis for en frugtbar udvikling. Journalen over den daglige post + telefonopringninger kan godt löbe op til 10—20 henvendelser om dagen.

Der er bogstavelig ikke grænser for, hvad BA spörges om:

En privatmand, en virksomhed eller et vandværksinteressentskab påtænker en boring: hvorledes er de geologiske forhold på dette sted, hvor dybt skal der bores og hvad slags vand findes der? Eller en bröndborer skal afgive tilbud på udförelsen af en boring, og så kommer han med de samme spörgsmål (dette er langt det almindeligste). — På atlasbladet ser man, hvilke boringer der findes på den pågældende lokalitet, og de tilsvarende profilblade tages frem. Muligvis er sagen så vel oplyst, at man ligefrem kan svare, at vandförende kalk træffes i den og den dybde, og grundvandspejlet vil stille sig et vist antal meter under terræn, hvilket altsammen tillader entreprenören at kalkulere m. h. t. boreomkostninger og pumpe.

Er sagen mere tvivlsom, holdes svaret i mere almindelige vendinger, med fremhævelse af usikkerheden og de overraskelser, man altid kan risikere; men selv en sådan orientering er af stor værdi.

Muligvis drejer det sig om en egn, hvor ikke-vandförende lerlag af stor mægtighed kan ventes (f. ex. visse tertiære lerarter, der kan opgå til flere hundrede meter). I så fald adviseres de interesserede parter om dette, og det aftales, at bröndboreren holder D G U underrettet om arbejdets gang og indsender pröver; arbejdet kan da tilrådes standset i rette öjeblik og boringen flyttes til et nyt sted.

Sagen kan også dreje sig om en gammel boring, hvis ydeevne er gået ned, eller som burde kunne give mere vand. Så henvender indehaveren sig til BA, som hurtigt har rede på evt. svingninger i grundvandstanden, udsigterne for öget vandtilgang ved uddybning af boringen, — eller helt enkelt kommer til det resultat, at filtret i borehullet skal renses. Ikke sjældent föres der retssag om brönde eller boringer, hvis ydeevne ikke er tilfredsstillende, og så er det igen D G U, der tilkaldes. — I alle tilfælde, hvor tekniske forhold kommer ind, henvises den pågældende naturligvis til at rådföre sig med sin ingeniör.

Meget ofte kommer henvendelsen til BA under arbejdets gang. Man er med boringen kommet ned i en vis dybde, men vand har man endnu ikke fået; hvad nu? — Så rekvirerer BA naturligvis de foreliggende borepröver, skönner over situationen og afgör, om boringen bör föres dybere ned eller flyttes, og i så fald i hvilken retning.

I alle de tilfælde, jeg hidtil har nævnt, er det indlysende, at der er ökonomiske hensyn at tage; også hensyn til det faktum, at hver time, arbejdet står stille, koster penge. Alt arbejde fra BA's side forceres derfor mest muligt; svar afgives pr. telefon med efterfölgende skriftlig bekræftelse.

En stor del af BA's virksomhed består i at bistå ved projekteringen af större arbejder: industrielle virksomheder, vandværker til större byer o. l. De fleste stæder i Danmark har fået vandværk (baseret på grundvand) omkring 1880—1900. Man har dengang ment, at når vandet var fundet, nogle boringer udfört o. s. v., så var den sag i orden for al fremtid. Nu — en eller to menneskealdre senere — er byens indbyggerantal vokset, industrierne i byen ligeså, og alt vand indenfor det oprindelige grundvandsområde beslaglagt. Så henvender stadsingeniören eller kommunalbestyrelsen sig til BA, hvis förste opgave ofte bliver at overbevise sagens parter om, at problemet ikke kan löses ved vedblivende at bore på det gamle område: helt nye indvindingsområder må söges, ofte langt fra byen. Så fölger udredningen af hele egnens geologi set fra grundvandssynspunktet, anbringelse af pröveboringer, udarbejdelse af vandrejsningskort, undersögelse af vandets kemiske sammensætning og tilrettelæggelse af det endelige projekt, — alt naturligvis i intimt samarbejde med stadsingeniören eller det projekterende ingeniörfirma. På denne måde kan BA have 50—100 små og store sager löbende til enhver tid, med stadig indströmmende rapporter, pröver, analyser og korrespondance.

Af alt dette fremgår, at BA's egentlige idé (som statsarkiv) ikke alene — eller i förste række — er at være et arkiv for opbevaring af tilvejebragte oplysninger. Idéen er fremforalt at være et levende, upartisk og derfor af alle parter tillidsfuldt benyttet organ i det praktiske livs tjeneste. Skulde BA være et stövet og dödt arkiv, kunde det ledes af en tör registrator; skal det fungere i samfundets tjeneste, kan det kun skabes og ledes ved intimt og fortroligt samarbejde med alle boreentreprenörer, ingeniörer og disses kunder. Det er ikke BA's tekniske side, der er det væsentlige; det alt overskyggende er dets menneskelige ledelse og lederens indstilling overfor opgaverne.

Jeg brugte ordene »tillidsfuldt benyttet». Det hörer til dagens orden, at der opstår uenighed eller gensidig mistillid mellem f. ex. boreentreprenören eller den projekterende ingeniör og en opdragsgiver (f. ex. et usagkyndigt kommunaludvalg), der ikke kan forstå, at en sag kan kræve udförelsen af adskillige pröveboringer, der koster mange penge. Så henvender man sig til BA, for alle ved, at BA ikke er ökonomisk interesseret i sagen. Den pågældende geolog rejser til stedet, holder orienterende foredrag og besvarer indgående alle spörgsmål, — og sagen glider i orden.

I denne sammenhæng er det værd at understrege, at al service fra BA ydes absolut vederlagsfrit. BA existerer i sin nuværende form på basis af vandforsyningslovens indberetningspligt, og heraf fölger til gengæld pligten til vederlagsfri service. I det höjeste betaler rekvirenten geologens rejseomkostninger igennem D G U's kontor, mens det er BA's funktionærer absolut forbudt at beregne sig honorar for ydet arbejde. — Det er altså staten, der betaler driften af BA, — men det tör vist siges, at de 15—20 000 kr. om året, BA koster i lönninger og driftsudgifter, er en beskeden udgift i forhold til den samfundsmæssige nytte. Alene det at forhindre udförelsen af nogle få, på forhånd udsigtslöse boringer ækvivalerer dette belöb.

På baggrund af denne redegörelse for BA's virksomhed kommer jeg endelig til en sag, der må fremhæves, — ikke som noget tilfældigt, men som et principielt faktum, der er lige så livsvigtigt for BA's existens som den juridiske lovparagraf, ja måske endnu vigtigere. Det er vexelvirkningen mellem BA og alle vandværksbranchens ingeniörer og bröndborere.

Det nævntes för, at almenheden har meget ringe kendskab til den juridiske indberetningspligt (de kan jo endda tage sig den let p. g. a.

de manglende straffebestemmelser), og bröndborerne, som ganske vist kender loven, har overhovedet ingen pligter. Propaganda alene har kun ringe virkning, — men nu kommer netop BA's rådgivende virksomhed til. Selv den mest uvillige og indesluttede bröndborer kommer nu og da i en situation, hvor han tvinges til at rådföre sig med DGU, og så har vi ham: lige for lige! Vi hjælper gerne dig, men til gengæld forlanger vi oplysninger om dine boringer! — I almindelighed er en så drastisk fremgangsmåde iövrigt ikke påkrævet. Langt de fleste bröndborere og ingeniörer har forlængst indset, at hvis de skal have nytte af BA, må de på deres side göre alt for at lette BA's arbejde. Mange af dem betragter vist egentlig BA som deres eget arkiv, — en indstilling vi kun kan glæde os over, for i realiteten er den jo rigtig, da det er samfundet, der betaler det hele. Man er klar over, at geologerne jo hverken er »fjernsynede» eller kan være allestedsnærværende; så skal BA kunne være i stand til at besvare spörgsmål, må det også forsynes med det bedst mulige materiale.

I denne sammenhæng er det interessant at lægge mærke til, at alle disse industriens og det praktiske erhvervs mænd er fuldkommen klare over den ulöselige sammenhæng mellem videnskabelig forskning og rent praktisk arbejde, — ofte i höjere grad end bevillingemyndighederne! Det intime samarbejde, hvorved BA ofte fölger en borings udförelse dag for dag, bringer os undertiden i den situation, at vi må sige: »Ja, nu har denne boring ganske vist givet det önskede resultat og I har fået den vandmængde, I skulde bruge; men set fra geologens synspunkt, befinder vi os netop på et sted, hvor vi har den störste videnskabelige interesse i at få opklaret, hvad de næste 10—20 m vil bringe.» Og så oplever vi gang på gang, at bröndboreren borer videre, enten på yderst favorable vilkår for DGU eller helt på egen bekostning, — blot for at fremskaffe de bjergartspröver, geologerne önsker. — Den ene villighed er den anden værd!

Geologisk Forskning. Nu er vi nået til det spörgsmål, i hvilken grad BA tjener den geologiske forskning. Forskningen består jo först og fremmest i at tilvejebringe reel viden, indsamling af fakta; og alene på dette stadium er det indlysende, at BA's personale erhverver sig et detailleret kendskab til landets geologi, blot ved år efter år at indregistrere 1 000 eller 2 000 boringer årligt. Imidlertid får dette uhyre materiale först sin virkelige værdi, når det kan utgöre basis for mere systematisk arbejde.

Blandt de videnskabelige arbejder må tilvejebringelsen af et kort over Danmarks prækvartære undergrund regnes for den vigtigste. Det er jo ikke nogen ny opgave; geologer har arbejdet på den sålænge, der har været geologer i Danmark, også med benyttelse af boringsobservationer, — al den stund denne sidste vej er den eneste farbare i et land som Danmark, hvor istidsaflejringerne overalt dækker de ældre formationer, og hvor prækvartære daglokaliteter er sjældne. Afsluttet bliver denne opgave jo heller aldrig; hvert år bringer nye boringer oplysninger, der tvinger os til at ændre formationsgrænserne; men med mellemrum lader materialet sig jo sammenstille til et nyt og bedre kort, f. ex. det undergrundskort, der i 1939 publiceredes af Theodor Sorgenfrei (BA's nuværende leder).

Det simple to-dimensionale »kort» er jo imidlertid ikke hele sagen. Udredningen af prækvartærets stratigrafi og tektonik er en langt större opgave, og netop på disse felter har de senere år bragt os længere frem — og samtidig stillet os större opgaver — end vi drömte om for 25 år siden. Rosenkrantz påviste allerede 1925 (ved hjælp af borematerialc) forkastninger i undergrunden under Köbenhavn, og i 1926 tillod jeg mig at fremsætte den thesis, at »Danmarks fysiske geografi må i höjere grad, end man hidtil tænker sig, anses for at være påvirket af forstyrrelser i den prækvartære undergrund». I de senere år bringer hvert eneste år bidrag til belysning dette nu anerkendte faktum, — bidrag der næsten alle baseres på udnyttelse af BA's stadig voksende materiale.

Vort kendskab til stratigrafien indenfor samtlige tertiærets afdelinger er blevet stærkt udvidet, og det samme gælder kridtet; her naturligvis först og fremmest daniet som det lettest tilgængelige, men også skrivekridtet og de underliggende formationer, efterhånden som borematcriale tilvejebringes.

Et kapitel for sig udgör arbejderne vedrörende de prækretaciske formationer, — det store og stadig mere brændende spörgsmål i dansk geologi. Opdagelsen af forekomsten af saltholdigt mineralvand afslörede på een gang forekomsten af saltförende aflejringer i den dybere undergrund og forekomsten af brud, hvorigennem saltvandet trænger frem. En systematisk bearbejdning af mange tusinde vandpröver fra boringer viste, hvor udbredt fænomenet er; men iövrigt må den videre udforskning af hele dette problem selvfölgelig baseres på såvel boringer som geofysiske undersögelser, og alt dette er godt i gang såvel fra danske instituters side som fra »Danish American Prospecting Co's» side.

I forbindelse med dette spörgsmål om saltvandet kan der være anledning til at nævne, at det har været os muligt at tilvejebringe en forelöbig oversigt over danske grundvandstyper i det hele taget. »Vand» er ikke slet og ret »vand», — det varierer overordentligt i kemisk sammensætning, selv indenfor et så begrænset område som Danmark. Det havde vandværksteknikere og den kemiske industris mænd jo nok vidst för, men en systematisk oversigt og opdeling af grundvandet i typer, hvis optræden lod sig bringe i årsagssammenhæng med geologien, var först mulig på grundlag af et omfattende BA. Fra alle landets laboratorier indsamledes mange tusinde vandanalyser; disse bragtes såvidt muligt i relation til de boringer, hvorfra de hidrörte, og yder-igere suppleredes dette materiale med D G U's egne analyser af indkommende vandpröver. Resultatet blev som nævnt en geologisk velmotiveret oversigt over vandtyper og deres optræden, — et resultat, der igen har været til största nytte i det praktiske liv. (Foredragsholderen genemgik en del exempler på danske grundvandstyper og hen-edte bl. a. opmærksomheden på overensstemmelsen mellem danske forekomster af »regenenerationsvand» med stor hårdhed og Höllviksboringernes calciumkloridrige saltvand.)

Öjeblikkelige Opgaver. Et kapitel for sig udgör D G U's arbejde på at fremskaffe brændsel under denne krig. På Bornholm findes som bekendt jurakul; men de har været kendt og underkastet brydning i over 300 år, så alle tilgængelige kul var brudt. Nu stilledes D G U overfor det spörgsmål, om der endnu kunde findes kul på Bornholm. BA lå inde med en række optegnelser om ældre boringer, og dette materiale suppleredes med borematerial fra det selskab, der havde brydningsret på de omhandlede arealer. Hele materialet underkastedes geologisk bearbejdning, 45 pröveboringer udförtes under D G U's ledelse, og man fandt såvel et nyt leje, der nu underkastes udnyttelse, som »fortsættelsen» af de gammelkendte flötser, der viser sig at indeholde ikke ubetydelige fremtidsreserver.

I Jylland vidste vi, at de tertiære brunkul forekommer alleröverst i ertiæret, på grænsen mellem miocæn og pliocæn, i realiteten umiddelbart under kvartæret. Dette indebar, at skulle en systematisk efter-ögning på grundlag af alle tænkelige muligheder gennemföres, måtte man lægge kendskabet til beliggenheden af tertiærlagenes overflade til grund. Materialet til dette kendskab fandtes i D G U's BA, og en sammenstilling heraf (foretaget af Keld Milthers) gav en niveaumæssig remstilling af tertiæroverfladen. Sammenholdt man dette med de nuværende terrænforhold, var det næste skridt at afgrænse de arealer, hvor tertiæroverfladen kunde ventes at være dækket af höjst 10 m stidslag, — og et kort herover angav altså umiddelbart de egne, hvor der var teoretisk mulighed for at finde brunkul inden 10 m's dybde.

Et systematisk borearbejde blev nu iværksat af D G U under Keld Milther's ledelse. Hidtil er der bevilget over 500 000 kr. til dette, og der er udfört over 3 000 pröveboringer. Resultatet er, at mens man ved krigsudbruddet kendte lejer med et samlet indhold af ca. 6 mill. ts. brunkul, og mens man indtil udgangen af 1943 havde gravet 5.5 mill. ts., kender vi nu lejer med en reserve på ca. 28 mill. ts. (heraf har D G U selv fundet lejer med 16 mill. ts.; private entreprenörer har fundet 12 mill., men for en stor del på basis af D G U's eftersögningsprogram).

Kvartæret er imidlertid ikke blevet glemt. Der fremkommer selvfölgelig gennem BA's arbejde mellem år og dag en mængde detailoplysninger om kvartæret, og jeg skal i denne sammenhæng indskrænke mig til at nævne de bidrag, der i de senere år er fremkommet til vort kendskab til de forskellige interglacialaflejringer. Mange nye forekomster af interglacial på primært eller sekundært leje er fundet, og efterhånden, som de sammenstilles, fuldstændiggöres billedet af eemhavets udbredelse, eemsundene tværs over Slesvig og udbredelsen af sidste interglacialtids »Kattegat»: Skærumhedeseriens udbredelse fra det nordlige Jylland ned gennem Kattegat, over Sjælland og Ven og videre over Mön-Rügen og over Balticum (Zæns) til Hvidehavet (?).

Udnyttelsen af den naturgas i Vendsyssel, der har sin oprindelse netop i de interglaciale, marine aflejringer, har taget et enormt opsving under krigen. D G U har her bidraget ved at klarlægge gassens stilling i geologisk henseende (netop interglacial gas, ikke gas fra oljeforekomster) og derved bringe dens udnyttelse ind i rationelle baner. — Et særligt problem her var spörgsmålet om sikkerhedsmomentet: Den yderst explosionsfarlige gas viste tilböjelighed til at vagabondere p. g. a. fejlagtigte boremetoder, men ved D G U's indgriben blev der fastsat regler for gassens udnyttelse og indfört effektivt tilsyn.

Alt dette sidst fremförte har understreget det faktum, at det er umuligt at skelne mellem praktisk eftersögning af nyttige råstoffer og videnskabelig, geologisk forskning. Og som instrument til begge dele har D G U's BA vist sin overordentlige effektivitet. — At der ustandseligt arbejdes med henblik på fremtiden, behöver jeg næppe at understrege. Af store opgaver, der forberedes, skal jeg kun pege på nogle enkelte: Successiv tilvejebringelse af niveaukort over prækvartæret over hele Danmark; ligeledes niveaukort over grundvandsstanden; etablering af et net af pejleboringer over hele landet, så man kan fölge svingningerne i grundvandstanden; kemisk-hygiejniske undersögelser over drikkevand på landet; indsamling af bjergartspröver til fortsat udredning af prækvartærets stratigrafi; indsamling af morænelerspröver til stentælling, analyse af tungmineraler og analyse af pollen på sekundært leje i morænen (alt dette skulde efterhånden give os bedre kendskab til de forskellige nedisninger og deres moræner); og endelig fortsættelse af allerede påbegyndte kontrolforsög med »önskekvist-

mænd» (slagruta). Dette sidste lyder som et kuriosum, men det er desværre et kuriosum, der årligt koster landet store summer; udredning af dette problem og oplysning om det er altså arbejde, der ligger helt på linje med BA's övrige arbejder.

Opgaver kommer BA's geologer aldrig til at savne. Just den intime forbindelse mellem geologerne og det praktiske livs mænd gör, at de praktiske opgaver ustandselig melder sig af sig selv; og det videnskabelige stof vælter bogstaveligt ind i form af boreprøver og oplysninger. Det er virkelig en misundelsesværdig opgave for den rigtige geolog at være leder af et så fængslende arbejdsfelt som D G U's borearkiv.

Med anledning av föredraget yttrade sig hrr Brotzen, A. Gavelin, Troedsson, Geijer, Petersson, J. Eklund och Mohrén.

Hr Sven G. Petersson: Jag ber först att få ansluta mig till tidigare talare och till föredr. framföra mitt tack för det intressanta föredraget.

Jag kan nämna, att vi redan haft praktisk nytta av den organisation, som dr Ødum ordnat i Danmark. Då vi nämligen omkring 1933 skulle börja utföra borrning i Skåne, funno vi, att någon samordning av de geologisk-hydrologiska frågorna icke tidigare gjorts, och att det endast var synnerligen elementära uppgifter man kunde erhålla från de resultat, vilka uppnåtts vid samtliga borrningar utförda av lokala entreprenörer. Hr Ødum angav då vissa riktlinjer för det sätt, varpå han trodde att vattenfrågan lämpligen skulle behandlas i Skånes kritområde, och är det mig en angenäm plikt att nu konstatera, att de råd och anvisningar, som hr Ødum, icke blott vid detta tillfälle utan även i andra fall, lämnat varit av stort värde vid de brunnsborrningar, som utförts i Skåne. Efter denna linje ha sedan noggranna geologiska arbeten utförts i samråd med geologer bl. a. dr Brotzen och vi anse nu, att vi i stora drag löst de hydro-geologiska problemen inom SV Skånes kritområde.

Beträffande provtagningen ber jag få framhålla, att vi med hänsyn till de olika förhållandena i viss utsträckning utföra denna på annat sätt här i landet, än vad som göres i Danmark. Här utföres borrning på två olika sätt, dels diamantborrning, där kärnprov utvinnas ur den genomgångna berggrunden, vilken metod användes vid undersökning av malmfyndigheter samt strukturundersökningar av exempelvis den typ, som utföres vid Höllviken, dels brunnsborrning efter vatten. I det senare fallet erhållas icke sammanhängande kärnprov utan endast slam och i enstaka fall hela bitar av det genomborrade materialet. Här i landet finnas ett 100-tal små diamantborrmaskiner, varför man torde kunna räkna med att åtminstone de första krigsåren omkring 150,000 m diamantborrning utfördes per år. För närvarande är omfattningen av diamantborrningen av olika skäl avsevärt mindre. Borrkärnor från sådana borrningar förvaras i allmänhet vid respektive gruvor eller vid centrallaboratorier. När borrningar utföras på kontrakt äro kärnorna givetvis uppdragsgivarnas egendom och upplysningar i någon form varken få eller kunna därför lämnas av entreprenören.

Brunnsborrningar utföras här i landet efter två olika metoder. Den äldsta är spolborrningsmetoden av den typ med vilken borrningar utföras i Danmark.

Denna metod användes hos oss i Skåne samt på Öland och Gotland. Vi uppskatta antalet sådana utrustningar till mellan 30 och 40, ifrån de mest primitiva upp till maskindrivna aggregat. För brunnsborrning i urberget och andra hårdare bergarter användas stötborrmaskiner av den typ, som Diamantborrningsbolaget utexperimenterat. Vi räkna med att det sannolikt torde finnas 150 st. sådana maskiner spridda över hela landet. Totalt torde väl med båda metoderna borras mellan 50,000 och 60,000 meter per år.

Vid de borrningar Diamantborrningsbolaget utför inhämtas noggranna rapporter över de utförda arbetena. Förmännen skola sålunda för varje vecka till kontoret rapportera hur många meter, som borrats under föregående vecka, lämna uppgift på genomgangna bergarter, erhållna vattenmängder etc. Vid slutet av varje borrning sammanställas på vår geologiska avdelning resultaten av borrningarna, vilka slutligen sammanfattas i en lista, som publiceras. Prov uttagas från alla borrningar, som utföras i andra bergarter än urberg. Dessa prov insändas till vårt kontor och sedan vi själva tagit del av desamma, överlämnas de till S. G. U. eller till geologer, vilka ha speciellt intresse av dem. I en del fall behålla vi emellertid proven själva för behandling av vissa speciella områden. Under senare åren ha även utförts omfattande borrningar i kvartära lager för undersökning av vattentäkter för städer och samhällen. Prov från dessa undersökningar inom grusåsar etc. förvaras av stadsingenjörskontoren och i en del fall av AB Vattenbyggnadsbyrån i Stockholm.

Vi ha, som jag förut nämnde, ett omfattande arkiv hos Svenska Diamantborrningsbolaget över utförda borrningar samt även bergartsprover, och äro geologerna alltid välkomna, att när som helst komma upp till oss och gå igenom det material, som vi uttagit från våra brunnsborrningar. För att lämna en uppfattning om vilken storlek det skulle röra sig om vid en eventuell provtagning här i landet av den typ, som göres i Danmark, skulle jag vilja lämna följande uppgifter: Om vi utgå från att prov endast tagas från berggrund, som är yngre än urberget, och räkna med att det inom detta område borras omkring 30,000 meter per år samt att prov uttagas från varannan meter borrning, skulle det följaktligen komma att röra sig om minst 50 prov per dag, vilka skulle insamlas och behandlas vid en central institution. Som jämförelse kan nämnas, att vid D. G. U. omkring 10 prov behandlas per dag.

Hr Troedsson uttalade ett tack till föredr. för den värdefulla framställningen och underströk vikten av en organisation i Sverige liknande den danska för tillvaratagande av det rika material, som dagligen kommer fram vid borrningar men som nu till allra största delen går till spillo. Den lagstiftning rörande grundvattnet, som här genomfördes för några år sedan, har beklagligt nog icke tillvaratagit de möjligheter i denna riktning, som man hoppats på, vilket väl huvudsakligen torde bero på att den utarbetats utan någon som helst kontakt med den geologiska vetenskapen. Tal. erkände villigt och med tacksamhet den generösa inställning till forskningen, som Diamantborrningsbolaget ständigt visat genom att lämna ut material till undersökning och även genom att i allt större utsträckning taga provserier vid sina borrningar. Även andra företag hade insett betydelsen av att systematiskt tillvarataga borrkärnor. Så har Höganäsbolaget under senaste år lagt upp ett överskådligt och välordnat borrarkiv, som kommer att bli av stort värde för forskningen lika väl som för bolagets egen framtida verkmhet. Såväl härifrån som från Hälsingborgs stads vattenborrningar hade uplettserier frikostigt ställts till tal:s förfogande, vilka äro avsedda att verlämnas till S. G. U. Ett centralt arkiv vore under alla omständigheter tt föredraga framför alla de privata eller kommunala provsamlingar, som n. uppläggges på skilda håll i landet och om vilkas vård och tillgänglighet örre eller mindre osäkerhet alltid måste råda. Framför allt borde vid en rkivering av detta slag tillvaratagas borrningar i kvartären och inom om- iden med sedimentär berggrund.

Geolognytt.

Fornminnesföreningen har tilldelat fil. dr K. E. Sahlström Hildebrandska riset för mångårig verksamhet inom arkeologien.

K. Vetenskapssocieteten i Uppsala har utdelat 1944 års Linnépris till do- ent Ivar Hessland för hans avhandling Marine Schalenablagerungen Nord- ohusläns.

Bergsingenjör Hans Lundberg har av American Society of Swedish En- neers tilldelats John Ericsson-medaljen.

Geological Society of London har tilldelat prof. V. M. Goldschmidt Wol- stonmedaljen för hans framstående bidrag till norsk petrografi och hans rundläggande undersökningar över kristallstrukturen och fördelningen av e kemiska grundämnena i jorden.

K. Vetenskapsakademien har ur Hierta-Retzius' stipendiefond för veten- kapliga ändamål tilldelat lektor Einar Teiling 1,500 kr för limnologiska un- ersökningar i mellersta Sverige; fil. mag. Sigvard Lillieroth 800 kr för limno- giska undersökningar i nordvästra Skåne; fil. lic. Stig Waldheim 800 kr r fortsatt undersökning av de skånska myrarnas vegetation och ekologi; l. dr Sven Hedin 3,500 kr för bearbetning av botaniska samlingar från edinexpeditionen i Asien; samt fil. mag. Maj-Britt Florin 2,500 kr för en ndersökning av den senkvartära Viskafjordens fossila diatomacéflora.

K. Vetenskapsakademien har tilldelat fil. lic. Bengt Collini Letterstedtska nderstödet för maktpåliggande undersökningar, 400 kr, för att bearbeta aterialet från visingsöformationen samt för fältarbete inom samma forma- on.

Stiftelsen Lars Hiertas Minne har tilldelat docent Erik Nilsson 600 kr för rtsatta undersökningar av de gotiglaciala issjöarnas utbredning och land- ens avsmältningsförhållanden i södra Sverige; docent Carl Caldenius 1,000 till renritning av kartor och diagram och tryckning av en avhandling om landsisens avsmältning från södra delen av Tidadalen till nordspetsen av illingen; fil. lic. Olge Jungstedt Adamson 1,000 kr till tryckning av en av- ndling The petrology of the Norra Kärr district. An occurrence of alkaline cks in southern Sweden; samt laborator Sture Landergren 1,000 kr för rtsatta undersökningar om bors geokemi.

Liljewalchska stipendienämnden i Uppsala har tilldelat fil. lic. Bengt Collini 1,425 kr för fortsatta geologiska fältarbeten inom Vätternområdet; fil. mag. Sten Rudberg 1,000 kr för geomorfologiska studier i nordöstr Dalarna, huvudsakligen inom de subjotniska bergarternas område; samt fil kand. Bertil Waern 1,600 kr för undersökningar av rastritesledet i Dalarna Västergötland och Skåne.

Kungl. Maj:t har beviljat lektor O. Isberg ett forskningsunderstöd å 1 200 kr.

Kungl. Vetenskapssocieteten i Uppsala har ur de för året tillgängliga medlen av Bjurzonska understödsfonden för lärda verks utgivande tilldelat bl. a prof. Rutger Sernander ett anslag för utgivande av Kungsängens botanisk och geologiska historia.

Kuratorerna för Kungl. och Hvitfeldtska stipendieinrättningen ha ur överskottsfonden utdelat bl. a. 400 kr. till fil. kand. Gunnar Lindekrantz, Göteborg, för fortsatta undersökningar rörande ändmoräners former runt Kungsbackafjorden och 800 kr. till fil. dr Johan Alin för avvägning av stenålder boplatser och strandlinjer.

För vinnande av filosofie doktorsgrad försvarade fil. lic. Carl Erik Nordenskiöld, Lund, tisdagen den 18 april en akademisk avhandling med titeln Morfologiska studier inom övergångsområdet mellan Kalmarslätten och Tjust Som opponenter fungerade docenterna Sven Björnsson och Arne Sandell

Fil. lic. Olge Jungstedt Adamson försvarar lördagen den 13 maj kl. 10 f. m å Stockholms Högskolas lärosal nr 3 sin i detta häfte intagna avhandling Opponenter äro prof. Harry von Eckermann och fil. lic. F. E. Wickman.

Den 4. 4. 44 öppnades de sakkunnigas utlåtande över professuren i geologi särskilt petrografi och mineralogi, vid Uppsala universitet. Professor Backlund placerar de sökande i ordningen: 1) Krokström, 2) von Eckermann, 3 Norin, 4) Sundius. Prof. Hadding: 1) Norin, 2) Krokström, 3) von Eckermann och Sundius. Prof. Aminoff har ordningen: 1) Krokström, 2) von Eckermann, 3) Sundius, dock icke med tillerkännande av full kompetens: om Norin finner han det svårt att med bestämdhet uttala sig. Samtliga sakkunniga förklara Kulling inkompetent.

K. Fysiografiska Sällskapet i Lund har till utländsk ledamot kallat professor Thomas Barth, Oslo. Till inländsk ledamot har valts professor Helge Backlund, Uppsala.

Sveriges geologiska undersöknings fältarbeten 1944.

Statsgeologen S. Johansson utför agrikulturgeologiska och hydrogeologiska specialundersökningar

Statsgeologen R. Sandegren utför kartering på kartbladet Söderfors Extrageologer: O. Claesson och P. H. Lundegårdh.

Statsgeologen N. Sundius avslutar undersökningen av vissa karbonat bergarter i Södermanland och Närke samt påbörjar en undersökning av Dal formationens kvartsiter m. m.

Statsgeologen G. Lundqvist reviderar på kartbladet Avesta, rekognoscerar r jordartskartan över Kopparbergs län samt meddelar instruktion för nya artbladsrekognoscörer. Extrageologer: å kartbl. Avesta: B. Collini, G. lodkvist, E. Fromm och J. Lundqvist. I länskarteringen deltager assisten- n C. Larsson.

Statsgeologen B. Asklund övervakar berggrundskarteringen å kartbladet öderfors samt utför stenindustriella specialundersökningar i södra Sverige h i Jämtlands kambrosilurområde. Extrageolog (vid stenindustriundersök- ingar i södra Sverige) P. H. Lundegårdh.

Statsgeologen G. Ekström reviderar på kartbladet Lund samt utför ydrogeologiska specialundersökningar.

Statsgeologen O. Ödman utför malmgeologiska undersökningar inom orrbottens län.

Statsgeologen S. Hjelmqvist övervakar berggrundskarteringen på kart- laden Avesta och Falun samt reviderar å det förstnämnda.

T. f. museiföreståndaren P. Thorslund utför stratigrafiska undersökningar om Jämtlands kambrosilurområde.

Geologen S. Gavelin utför malmgeologiska specialundersökningar inom ästerbottens och Norrbottens län.

Geologen O. Kulling rekognoscerar å kartbladet Falun samt utför vissa mpletteringar för berggrundskartan över Västerbottens län. Extrageologer kartbl. Falun: A. Klementsson, E. Åhman och J. Öster.

Geologen W. Larsson reviderar berggrunden å kartbladet Vårvik.

Gruvingenjören K. A. Barkenberg leder de gruvtekniska arbetena.

Assistenten S. Werner leder de geofysiska fältarbetena i Norrland.

Docenten N. G. Hörner rekognoscerar å kartbladet Uppsala.

I den mån som beredskapshänsyn så föranleda, kunna utvidgningar eller dringar av planen förekomma.

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Geologiska Föreningens sekreterare, professor G. Troedsson, träffas i Föreninge angelägenheter i bostaden Bragev. 29, Djursholm, kl. 17—18, Tel. 55 20 10. Efter överenskommelse per telefon kan sekreteraren även träffas å Sveriges geologiska undersökni eller å Stockholms högskolas Geologiska institut.

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